THE *Petroleum* Engineer **Management Edition**

Exploration—Drilling—Producing • Refining—Petrochemical—Gas Processing • Oil and Gas Pipelining

OCTOBER, 1955 • VOLUME XXVII • NUMBER 11

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The Petroleum Engineer, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the Petroleum Industry, United States and Foreign, $6.00 per year; $10.00 for two years; $13.00 for three years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879.

XUM

Drilling Pace Quickens

It would be erroneous to say that one part of the petroleum industry has greater importance than another. Drilling, producing, pipelining, and refining are integral segments of this great business. However, with the American Association of Oilwell Drilling Contractors holding its annual convention in Houston this month (September) it is pertinent to consider the magnitude of the role played by the contract drilling fraternity.

Actually, it may well be said that "it all begins with drilling", for without producing wells there is, of course, no oil to transport through pipe lines or to process into fuels and other products at refineries and chemical plants. And, according to latest figures, approximately 93 per cent of present-day wells are drilled by contractors.

Heartening, then, is a look at the trend drilling activity has taken within recent months. Official figures show that on August 22 of this year there were 2967 rotary rigs in operation in the United States and Canada. On the comparable date a year ago (August 23) there were 2534 active rigs. This gain of 433 rigs is significant. It means the discovery of more reserves, the purchase of more equipment, the employment of more men . . .

Further probing into statistics reveals these interesting facts: The first seven months of this year 28,670 new locations were made, during the same period last year there were 26,321. Producing wells brought in this year through July numbered 15,678, and for last year 14,400.

This burgeoning activity, we think, is based on several realistic causes. Primarily, it is still possible for the drilling contractor to make an attractive profit despite sterner competition and greater technological and engineering requirements. Freedom of activity in the American tradition, a high degree of professional respect, and monetary rewards commensurate with ability are others.

The petroleum industry as a whole can be thankful for this healthy condition in its drilling branch. Pipe lines, those steel fingers that are constantly reaching out to connect new wells, are completely dependent for their existence on production being maintained at a high level domestically. Conceivably, refineries could be kept operating, in a manner, on imported oil, but economic and efficient operation are dependent upon ready, uniform supplies produced on the North American Continent.

Without minimizing the importance of all other branches let us, at this time, not be frugal with deserving praise to members of the contract drilling industry.

FRANK H. LOVE

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...The CAT* No. 583 Pipelayer!

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NEW IMPROVED STABILITY

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NEW HYDRAULICALLY ACTUATED COUNTERWEIGHTS

NEW HEAVY-DUTY CONSTANT-MESH PIPELAYER WINCH TRANSMISSION

NEW LIVE-SHAFT, CONSTANT-POWER DRIVE

For the first time you get a pipelayer that's *all pipelayer*—not a tractor attachment. It's Caterpillar's all-new No. 583.

Check the features listed above. They are answers to many of your problems because you helped design them. Caterpillar engineers worked closely with you of the pipeline industry in developing a unit to lick your own special problems.

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Boom and load line brake levers have handles easily distinguished by feel. Operators can use them and still watch the job for maximum safety. And the unit is powered by a 191-HP Caterpillar Diesel Engine, which includes a new block, a new fuel injection system, and a more efficient cooling system!

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CATERPILLAR LEADERSHIP IN ACTION

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

American Association of Oilwell Drilling Contractors has been selected by the National Safety Council to receive the Council's Association Award. Presentation of the award will be made at the National Safety Congress on October 19. Unanimous approval for the award was given by the Council's committee of judges.

★ ★ ★

East Coast independent unions operating in Esso Standard Oil's refineries have voted nonaffiliation with the Oil, Chemical and Atomic Workers Union International (CIO). The negative vote was given by members of the Independent Petroleum Workers of New Jersey, who indicated they "might" change their stand if a new contract, now being negotiated, is not agreed upon soon.

★ ★ ★

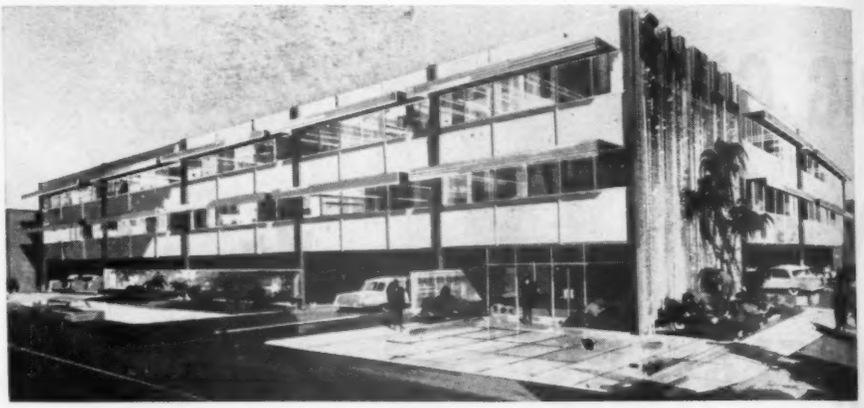
Oil Progress Week, which will begin Sunday, October 9, is being crammed to capacity with activities focusing the nation's attention on the oil industry's progress and its problems. Hundreds of film showings have been booked; company presidents and oil men are filling their schedules with luncheon speaking engagements; parades, Magic Barrel presentations, open house activities and refinery tours will highlight the week. See details, page E-24.

★ ★ ★

Taxes levied against petroleum operations and products by the various levels of government last year totaled nearly $5.3 billion, according to Chase Manhattan Bank (New York) tabulations. Assessed on each barrel of crude produced, the tax would be $2.02—or 71 per cent of the average price of crude at the well. Taxes paid by the petroleum industry and its companies have more than doubled during the past eight years.

★ ★ ★

Highway progress and gasoline taxes were reviewed at the fifty-third annual meeting of the National Petroleum Association. Nearly 1000 turned out for the session, where the refiners discussed everything from gas turbine engines to natural gas. Among featured speakers were T. S. Petersen (Standard of California), Admiral Radford (Joint Chiefs of Staff chairman), and B. Brewster Jennings (Socony Mobil).



Shell Oil Company's coastal division offices will soon move into this modern new structure in Ventura, California.

Official FPC ruling has been made assuming jurisdiction of gas sales made by independent producers before the gas is processed. Officials say the stand, made in the light of Supreme Court decision upsets previous interpretations of the Natural Gas Act. The act originally did not apply to the production of gathering of natural gas. The new ruling stipulates that jurisdiction is now warranted if any part of it ultimately moves in interstate commerce for resale.

★ ★ ★

Defense Mobilizer Flemming has issued written warnings to the 18 principal oil importers to trim incoming shipments back to safe levels—or else federal action will become imperative. The last cut-back plea by Flemming pointed out that while domestic crude production has increased 5 per cent in the first seven months of this year, crude oil imports have increased 15 per cent and residual oil has increased over 23 per cent.

★ ★ ★

Safety record of the petroleum tank truck fleets are among the best, according to National Safety Council figures just published. The group last year averaged only 1.22 accidents for every 100,000 miles traveled. This represents both city and inter-city operations; inter-city trucks averaged only 0.93 accidents for each 100,000 miles. The report also stated that tank trucks with capacities greater than 25,000 gal had two-thirds fewer accidents than smaller vehicles on the basis of gallonage delivered.

New State of California law (Cunningham-Shell bill) permitting oil and gas exploration in the California tidelands went into effect September 7. The law provides, with certain exceptions, the exploration for oil and gas can be carried on in coastal waters between Newport Beach, in Orange County, and Oceano in San Luis Obispo County.

★ ★ ★

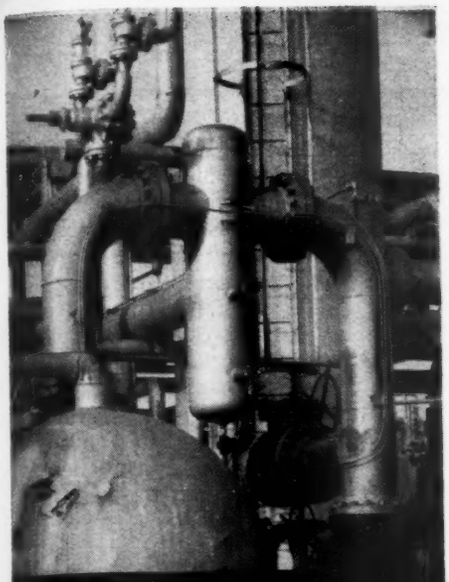
Standard of California's Argentina drilling contract may be revoked due to political dissention within President Juan Peron's party. A drilling agreement with Compania California de Petroleo, needed to increase Argentina's lagging oil production, has bogged down in the Peron-controlled congress. The contract was approved by the industry minister in April and sent to congress.

★ ★ ★

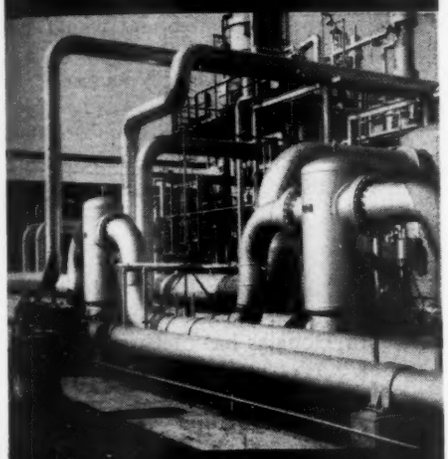
Safer and more economical methods of mining oil shale will be undertaken in the Bureau of Mines' new research program under a recent $1,000,000 appropriation from Congress. Tests will be run on two of the most promising methods to be developed at the Bureau's Rifle, Colorado, experiment station.

★ ★ ★

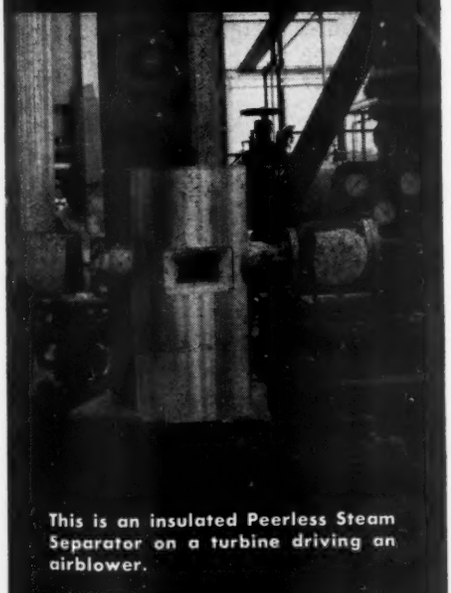
Canadian oil industry is now capable of producing 80 per cent of its oil requirements, according to new Canadian Petroleum Association statistics. At the present time the nation is spending over $400,000,000 for exploration and development in Western Canada as compared with only $15,000,000 in 1946.



A Peerless Line Separator is shown above removing entrainment from a refinery reboiler.



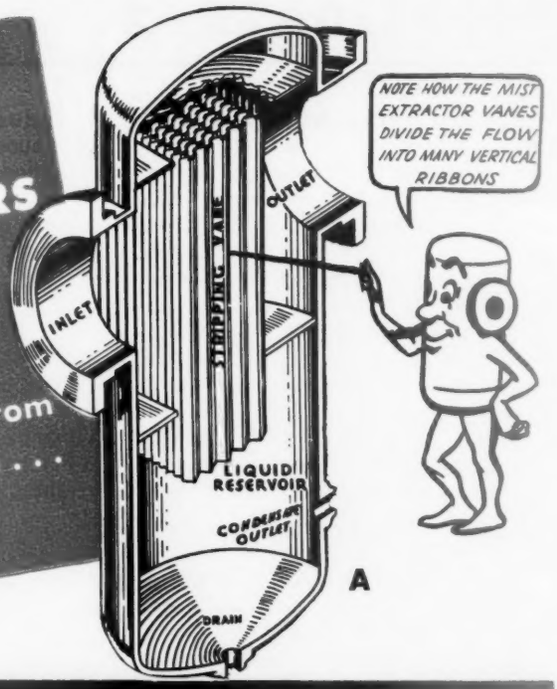
Peerless Line Separators are doing an effective job of mist extraction at this Kentucky Petrochemical Plant.



This is an insulated Peerless Steam Separator on a turbine driving an airblower.

PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .



B
FLOW
TOP VIEW
MIST COLLECTS INTO DROPS ON THE WET SURFACES
DROPS IMMEDIATELY ENTER DEEP POCKETS OUT OF GAS FLOW
DIRECTIONAL CHANGE AIDS IN LIQUID SEPARATION
TURBULENCE CAUSES EVERY MIST PARTICLE TO CONTACT STRIPPING VANE SURFACES
GAS IS STRIPPED DRY LONG BEFORE REACHING END OF VANES

HIGH EFFICIENCY—HIGH CAPACITY LOW PRESSURE DROP

Thousands of installations throughout the Refining and Chemical industry have proven the Peerless Line Separator principle to be one of the most outstanding methods available for the extraction of liquid from gas, steam or air.

Drawing A above shows the arrangement of the vanes in the Separator. Drawing B is an illustration of the Peerless principle.

The mist extractor combines the forces of impingement, centrifugal motion and surface tension to obtain its high efficiency. The path of the gas, etc., through the unit is constantly bending, causing semi-violent turbulence and rolling of the gas against the walls of the vane. Impingement and centrifugal force combine to contact the droplets with the vanes, where they coalesce, and surface tension then causes them to cling to the vanes' surfaces. Gravity and the impact of the gas stream then drives the droplets into the pockets where they roll down the vanes and out of the gas stream.

Through the Peerless method of mist extraction, the gas is stripped dry long before reaching the end of the vanes.

there's A PEERLESS SEPARATOR FOR EVERY REQUIREMENT

For any capacity
For any working pressure
For corrosive conditions
With removable vane units
With extra body length
With connections for accessory equipment
For pressure drop requirements of less than 6" water
For any vepor-liquid ratio
For any piping requirement

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FOR FURTHER INFORMATION ON THE USE OF PEERLESS LINE SEPARATORS PLEASE WRITE FOR NAME OF NEAREST PEERLESS ENGINEER.

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

XUM

Oil refining industry ranked first in number of cases of occupational dermatoses among 12 industrial groups under the jurisdiction of various state compensation boards. Of the 17,601 employees covered in a survey, 473 in the refining group reporter having some form of the disease. According to Association of American Soap and Glycerine Producers, Inc., chief cause is exposure to petroleum products and greases. Paradox lies in the fact that petroleum based cleansers, ointments, and creams are leading preventive and protective agents.

★ ★ ★

Merger plans are being studied that would combine facilities of three Michigan refining companies. Leonard Refineries, Inc., Alma; Roosevelt Oil and Refining Corporation, Mount Pleasant, and Mid-West Refineries, Inc., of Grand Rapids and Alma. An agreement, subject to approval of the stockholders and to several provisions, would transfer assets of Mid-West and Roosevelt to Leonard in consideration of the issue of securities by Leonard.

★ ★ ★

Membership in the Oil Industry Information Committee has exceeded the 30,000 mark, an increase of 66 per cent in the last 18 months. Roster of committeemen on January 1, 1954 listed 18,000 oil men. Stepped-up participation in the information program, sponsored by the American Petroleum Institute, has been widespread and rather general in all areas.

★ ★ ★

History of the American oil industry is being written under a special grant provided the Northwestern University by the American Petroleum Institute. Chief authors of the project are Dr. Harold F. Williamson and Arnold R. Daum. At present plans are for a two-volume survey encompassing the entire petroleum field.

★ ★ ★

Uranium claims are being tested by Phillips Petroleum Company in the Big Indian District in San Juan County, Utah on property owned by Republic Uranium Corporation and a Los Angeles, California, individual. Under the exploration agreement, Phillips will drill 40,000 ft of hole, receive varying degrees of interest in the development, and assume full responsibility for the mining of the property.

Industrial use of natural gas continues to rise above residential consumption at an increasing rate, Bureau of Mines figures indicate. In the first quarter of this year sales to industrial accounts exceeded the 989 billion cu ft mark, while residential customers used 930 billion cu ft. Field use and carbon black plants consumed 485 billion cu ft. Marketed production for the quarter reached nearly 5½ trillion cu ft, bringing into use more than 195 billion cu ft of gas that had been stored in Pennsylvania, Ohio, Michigan, West Virginia, and California.

★ ★ ★

Oil Producers Agency of California is seeking its first crude price increase in more than two years. Postings in California vary from $1.42 for 12-deg oil to $5.53 a barrel for 40-plus crude. Oklahoma producers have begun similar agitation for crude price hikes in the Mid-Continent area, the argument being based on increased prices on pipe, equipment, and labor costs.

Carl A. Young, former director of the production division of the American Petroleum Institute, died at his home in Dallas, Texas. A pioneer in the standardization of oil field equipment, he is also well known for his promotion of engineering studies and vocational training for oil field workers. He developed recommended testing, production, and supervisory practices. In the past he has been a vice president of the Lucey Supply Company, served under Herbert Hoover as Holland director of the Commission for Relief in Belgium in World War I. For this work he was awarded the Legion of Honor of France and the Order of the Crown of Belgium.

Failure of President Eisenhower's proposed highway legislation has stepped up, rather than squelched, work on the plan. National Oil Jobbers Council and other groups, which had opposed "users" method of financing, have agreed to "concentrate on preparing a constructive, affirmative plan" to be submitted to Congress next session. Otis Ellis of the NOJC suggests that the council would be ready in January to present a "workable and constructive formula" for construction of an adequate system of highways.

★ ★ ★

Indian government is considering construction of a $42,000,000 refinery under an Iranian and French proposal. To be built at Bhavnagar, north of Bombay in western India, the refinery would have a 1,500,000 ton annual crude capacity, and would be on a par with the India refineries of Burmah-Shell, Standard-Vacuum, and Caltex. A group of Bombay industrialists, National Iranian Oil Company, of Teheran, and Krebs, of Paris would finance the plant.

★ ★ ★

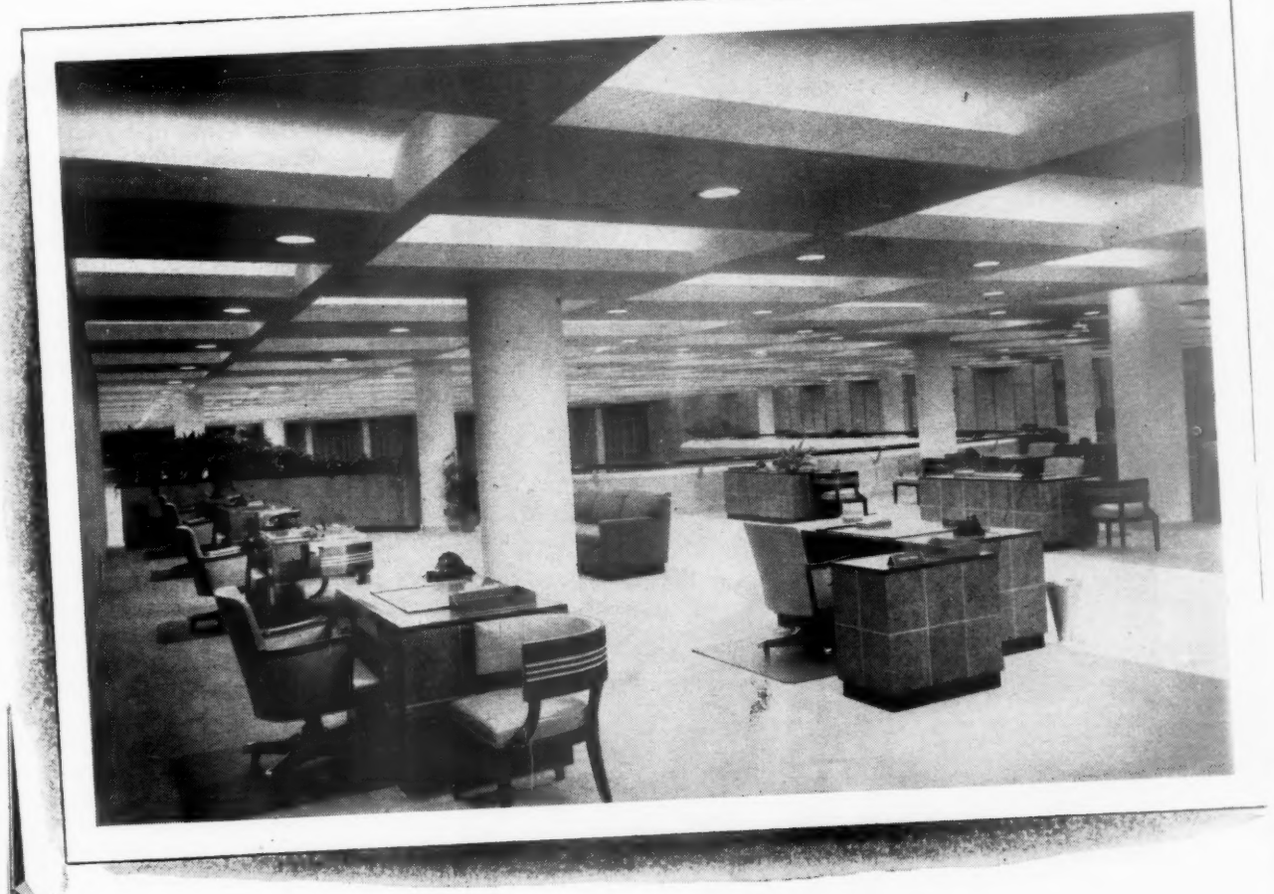
"Not a competitive industry" charge leveled against natural gas by Senator Douglas has met with opposition from several quarters. Douglas, opposing efforts to free natural gas from federal regulation, stated that "of the 4200 so-called independent producers, 174 produce more than 90 per cent of the gas." One independent producer, Sam T. Mallison, pointed out to the senator that: "three companies produce 100 per cent of our aluminum; 3 produce more than 90 per cent of our automobiles; about 6 produce 90 per cent of the steel; less than 6 produce over 90 per cent of our copper . . ." you have made no effort to impose federal control and price-fixing upon these industries."

★ ★ ★

American Petroleum Institute's division of production has established two new districts in the southwestern United States. The Southwestern district has been divided into two parts, known as the Southern and Southwestern districts. The Southern district will include the Texas Gulf Coast, East, South and Southwest Texas, Louisiana, Arkansas, and Mississippi. The Southwestern district will include West, West Central, and North Texas, and New Mexico.

XUM

WHERE OIL WELLS BEGIN . . .



This is a picture of a part of the Oil Department at Republic. Behind long lines of doors to the right and left is a complete staff of experienced oil men, engineers and geologists.

Behind *them* is the financial strength and the oil "know-how" of one of the first banks to make Oil Production Loans. Production loans originated here have helped add billions of barrels to the nation's oil and gas reserves — and have made the Republic "*The* Oil Bank" to oil men all over America.

This is YOUR Republic
Call it "My Bank"

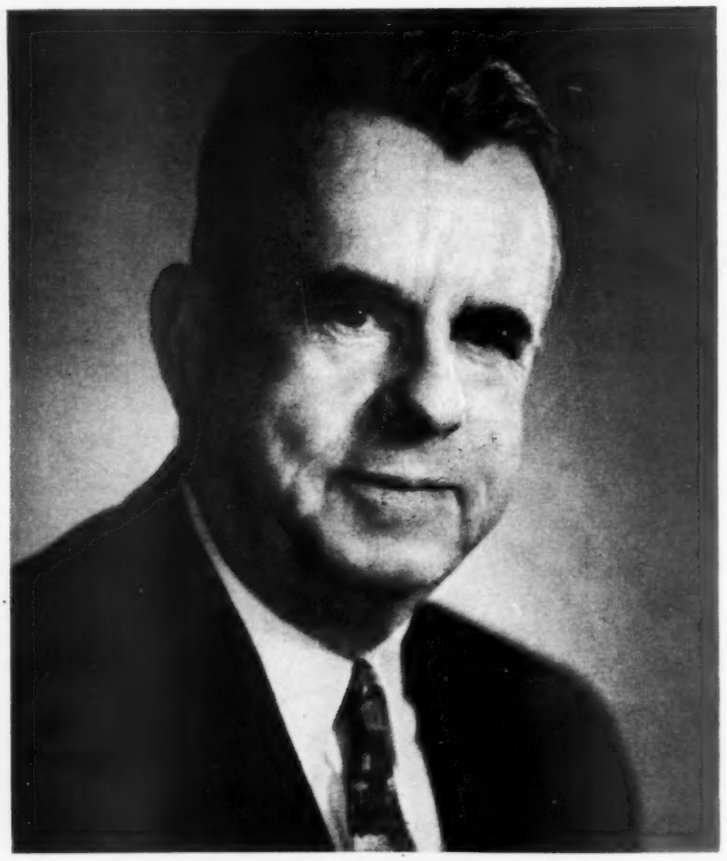
The Financial Center of the Southwest

REPUBLIC
NATIONAL BANK of Dallas

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

CAPITAL AND SURPLUS $60,000,000
LARGEST IN THE SOUTH

Petroleum Profile



A. W. THOMPSON

A. W. "TOMMY" THOMPSON is an adventurer—a very specialized adventurer. He will try anything in the drilling industry that might improve techniques or better conditions or operations for personnel.

Tommy has a wholehearted respect for the capabilities of the men in his industry and a deep-seated belief that the drilling operation can be streamlined to assembly line precision.

Thompson began his oil career after World War I. He resigned his commission as captain, FA, U. S. Army, to begin working in the engineering department of The Texas Company at its Port Arthur, Texas, refinery in 1919. He hasn't strayed from his career since —the petroleum industry, and especially drilling, for it is his business and his hobby unless you call his favorite pastime—eating—a hobby. His real hobby, Tommy says, is his grandchildren, and he has three . . . a boy and two girls.

The year after he began working for The Texas Company, Thompson was transferred to the South Oklahoma division of Wolverine Oil Company, a subsidiary, as field engineer. He was soon made assistant division supervisor.

Drilling contracting business lured him away in 1924. He was first a partner in Mohawk Drilling Company, with headquarters at Ardmore, Oklahoma, and later president of Mandeville and Thompson, Inc., with headquarters at Chickasha, Oklahoma. Then in 1939, he organized his own company and has been president of A. W. Thompson, Inc., drilling contractors and oil producers, from that year to this.

They have been fresh and invigorating years for the man with the inquiring mind and warm-hearted personality. Like all adventurers, he has trod new paths, and a surprising number of these trails have been broadened and leveled off by the numbers who have followed him. Some individuals who have not been able to carry out experiments in their own organizations have come to the easy-mannered Thompson, and he has tried out ideas not always his own.

One friend of his says it is hard to know what ideas are Thompson's because he is always planting them in other persons' minds and giving them full credit for the later growth.

Two items particularly appeal to this very specialized adventurer: Education and research. In his work with two organizations, American Petroleum Institute and American Association of Oilwell Drilling Contractors, he has for years stressed these two factors as vital to drilling programs.

He believes that education will develop the best kind of employees. All top executives in A. W. Thompson, Inc., Houston, Texas, came up from the ranks, some of them being with the company since its inception.

For three years, the company, which operates in Louisiana, New Mexico, Oklahoma, Texas, and the Rocky Mountain area, has had a training program. During that time, all tool pushers employed have been promoted from drillers and drillers have come up from roughnecks. It is no wonder that the president enjoys great personal respect and the company has earned the loyalty of its employees.

Thompson has held so many offices in industry organizations and has received so many honors, it would be impossible to name them all. He is now vice president of the division of production and a member of the board of directors of the American Petroleum Institute. Since he began taking an active interest in the API in 1930, he has served on numerous committees, working on standardization of rotary drilling equipment, on vocational training, and served on the American National Petroleum Council for two years. In 1950, he received the American Petroleum Institute Certificate of Appreciation.

He has performed many tasks for the American Association of Oilwell Drilling Contractors and filled several offices, including vice president at large and later president for two terms in 1951 and in 1952.

Thompson's special attention is given to AAODC's research and education program. This he believes in, and he combines a crusader's spirit with his venturesome mind. He wants everyone in his beloved industry to know more and to do better.

P 111.23

Illinois Oil Industry Active in Mid-1955

Alfred H. Bell

ILLINOIS oil production and oil drilling have been on the upgrade for about two years, after a downward trend lasting 13 years (Fig. 1). Estimated daily average production for the week ending June 11, 1955, was 234,100 bbl, as compared with a low during 1953 of 156,400 bbl per day for the week ending July 11, 1953, and an average daily production for the year 1953 of 162,000 bbl. The number of wells completed in 1953 was 2161, an average of 180 per month; in 1954 the average number of wells completed monthly was 271; for the first five months of 1955 it was 267.

For 3 years following the discovery of major oil production in the Illinois Basin in 1937, the state's production had an extremely rapid rise, from an annual rate of 4.5 million barrels to a peak of 147 million barrels in 1940. In the next 7 years, production declined to less than half the peak rate, after which it was nearly steady at around 60 million barrels a year until 1953.

It is now 50 years since major oil production began in Illinois. By a historic coincidence, 1905 was also the year the Illinois State Geological Survey began its work. The state's new oil industry was one of the first concerns of the Survey, and the excellent cooperation of the industry with the Survey, which began 50 years ago, has continued ever since.

EXCLUSIVE

History

According to published records, the first test drilling for oil in Illinois took place in Clark County (see Fig. 4) early in the decade beginning in 1860.

The Author

Alfred H. Bell is geologist and head of the Oil and Gas Division of the Illinois State Geological Survey, Urbana. A native of Canada, he received the degree of BA from the University of Toronto in 1917 and PhD from the University of Chicago in 1926. He served in Europe with the Canadian Overseas Expeditionary Force in World War I from 1916 to 1919. He worked as geological assistant on summer field parties of the Geological Survey of Canada in 1914 and 1920 through 1923. He was employed as geologist with The Texas Company in Kansas from 1924 to 1926, and since then has been with the Illinois Geological Survey.

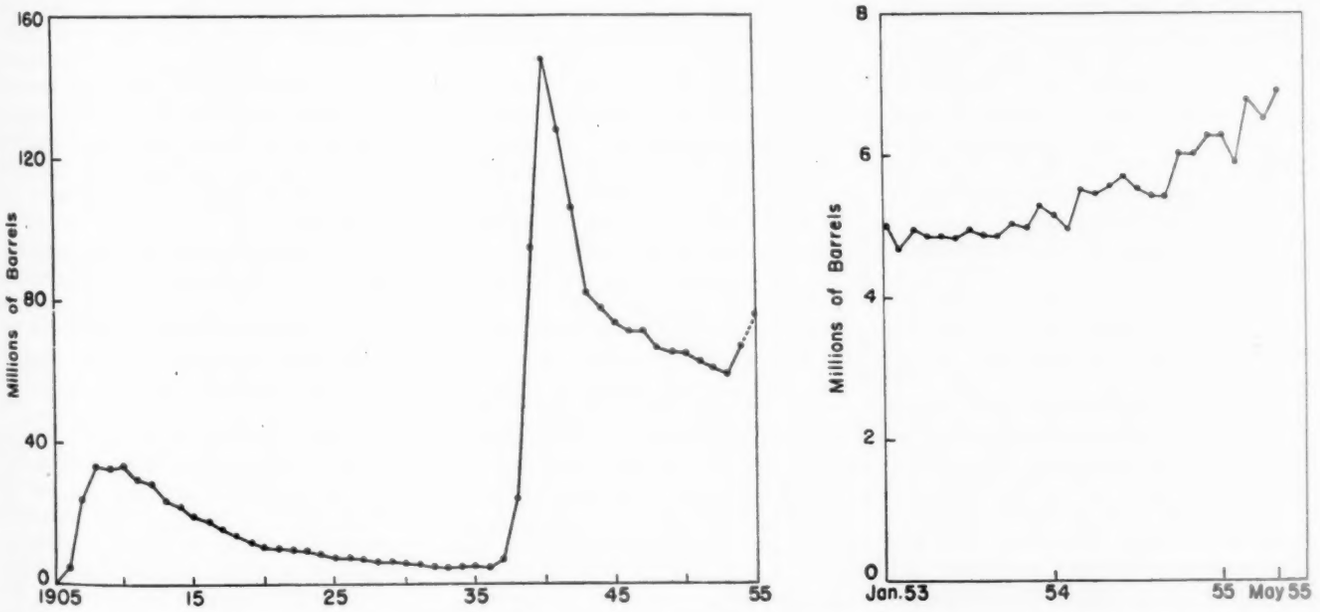


FIG. 1. Graph of annual oil production, 1905-1955, and monthly production, January 1953 through May 1955.

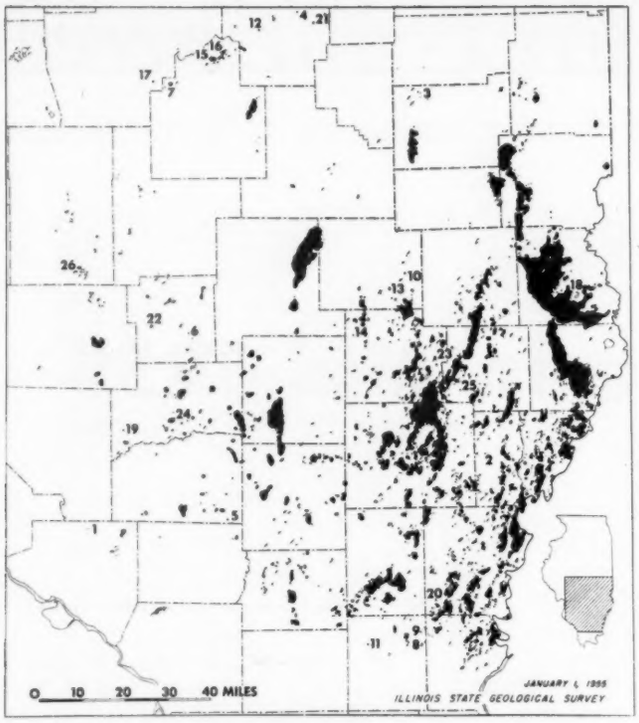


FIG. 2. Oil and gas fields of Illinois, January 1, 1955 (except Colmar-Plymouth field, McDonough County). Oil fields in solid black; gas fields in outline. Numbers represent fields discovered in 1954; see list.

About a dozen wells were drilled 8 miles north of Casey, the first of which was in Sec. 17—T11N—R14W, Clark County. Although these wells were in the area of the Westfield pool, they did not yield commercial oil production because the water was not cased off. Drilling was renewed in the area in 1904, and it opened up the Westfield pool located at the northern end of the Southeastern Illinois field in Clark, Crawford, Lawrence, and parts of adjacent counties.

In 1882 a gas well was drilled 2½ miles south of Litchfield, Montgomery County, and a few years later oil was discovered in the same area. According to the U. S. Bureau of Mines, oil was produced from 1889 through 1902, totaling 6576 bbl. In those years the Litchfield pool was the only oil-producing area in Illinois.

The Southeastern Illinois oil field was drilled chiefly between 1905 and 1912. Production reached a peak of 33.7 million barrels in 1908. Up to 1954 this field has produced half a billion barrels of oil. Up to the end of 1936, or before the discovery of oil in the Illinois Basin, this field had produced about 98 per cent of Illinois' oil. The remaining 2 per cent plus was from scattered pools in western Illinois, including Carlyle, Sandoval, Colmar-Plymouth, and Dupo.

The discovery of oil in Devonian limestone in the center of the Michigan Basin in 1928 (Mt. Pleasant field) caused geologists to consider seriously the possibility of oil in the untested central part of the Illinois Basin. This was suggested in a paper presented before the Illinois State Academy of Science in May 1930 and published in March 1931.* The economic depression of the early 1930's made it difficult to finance leasing and exploratory drilling and delayed operations for several years. Several oil companies made geological studies of the area in 1934, 1935, and 1936. Aerial surveys by reflection seismograph began in 1935. Much leasing was done and test drilling began late in 1936.

The first discovery well of oil in the central basin area was the Pure Oil Company's Weiler No. 1 in Sec 33—T3N—R8E, Clay County, completed February 26, 1937, with an initial production of 40 bbl from the Cypress formation, 2608-13 ft, Chester series, the discovery well of the Clay City field.

The first big producer was Pure Oil Company's Bunyan Travis No. 1, in the same section completed May 15, 1937, with an initial production of 2565 bbl from McClosky oolitic limestone, 2950-60 ft, in the Ste. Genevieve formation of Lower Mississippian series.

Activity in leasing, geophysical and geological work, and exploratory drilling immediately became intense and continued so for the next few years, resulting in a production peak of about 147 million barrels in 1940 (Fig. 1). Much of the state's production during the peak year was from cavernous Devonian limestone in the Salem and Centralia fields, where numerous wells had initial productions around 10,000 bbl. These wells had rapid early declines, which were reflected in a rapid decline in the state's daily production during the second half of 1940 and later.

In spite of these spectacular Devonian wells, the backbone of the Illinois Basin oil production is and has been from the Mississippian system, especially from sandstones in the lower part of the Chester series, as, for example, the Cypress, Benoist, and Aux Vases sandstones, and from the McClosky oolitic limestone in the Lower Mississippian series (Fig. 3).

Regional Structure

The Illinois oil-producing region occupies the larger part of a 55,000 square mile structural basin of Paleozoic rocks commonly called the Eastern Interior Basin, but also referred to as the Illinois Basin, even though it extends into Indiana and Kentucky. Illinois Basin is used in this paper to mean only the central deeper part of the Eastern Interior Basin, lying between the DuQuoin monocline on the west and the LaSalle anticlinal belt on the east (Fig. 5).

A cross-section of the Eastern Interior Basin with a small-scale map is shown in Fig. 6.

Occurrence of Oil

a. Geographic. The oil fields of Illinois are in the southern half of the state (Fig. 2), except for one field, the Colmar-Plymouth field in McDonough County, which is about 100 miles northwest of the main oil producing region. Much of the activity in the last two years has been in marginal areas, especially in Macon, Christian, and the adjacent parts of Sangamon counties on the north and in Saline County on the south.

b. **Stratigraphic.** An approximate division of Illinois' total oil production to date by geologic systems is shown in Fig. 3. The predominant place of the Mississippian system, with more than three-fourths of the total production, is noteworthy.

Ranking next in oil production is the Pennsylvanian system, in which the bulk of the production came from the 50-year-old Southeastern Illinois field. Relatively small amounts of Pennsylvania oil have been produced in scattered small pools in southwestern Illinois and in the faulted pools of the lower Wabash River area.

*Bell, Alfred H., The Relation of Geology to the Development of the Petroleum Industry of Illinois: Trans. Illinois Acad. Sci., v. 23, No. 3, p. 367-370, 1931.

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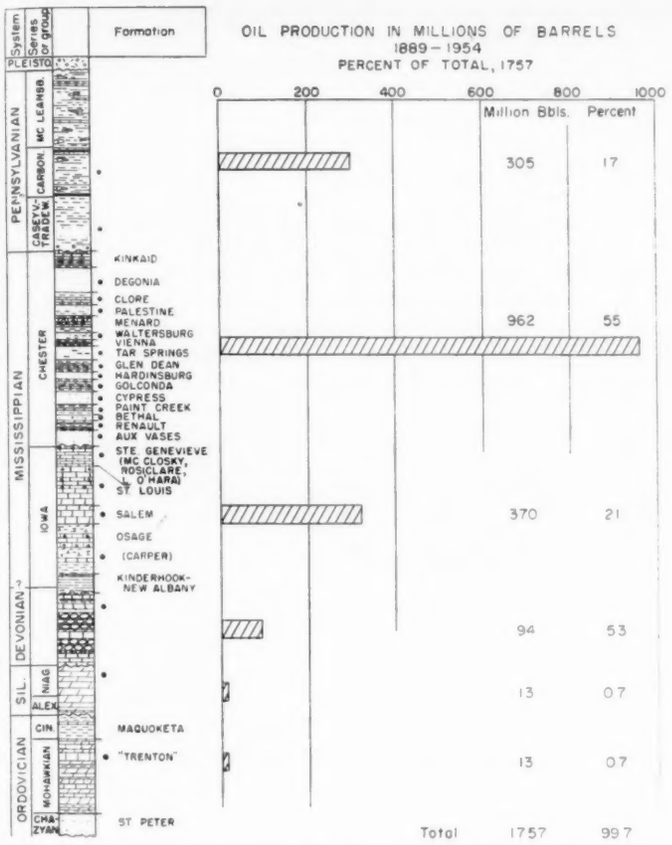


FIG. 3. Generalized geologic column showing oil-producing formations and amounts of oil by systems, 1889 through 1954.

FIG. 4. County index map of Illinois.

Third in rank is the Devonian system, which produces in about 32 pools, including the Salem and Centralia pools where the exceptionally large producers mentioned previously, were drilled.

Until the discovery, in 1943, of the first Silurian reef pool, the Marine pool in Madison County, the Silurian system had produced little or no oil in Illinois. With the discovery of more reef pools, the Silurian's total is now approximately equal to that of the Ordovician, which produces from the Trenton limestone in about a dozen pools. No oil has yet been produced from the part of the Ordovician below the Trenton nor from the Cambrian system.

c. **Types of reservoirs.** Oil in Illinois occurs mainly in sandstone and limestone reservoirs; an insignificant amount of oil may have been produced from fractured shale reservoirs. Most of the larger known oil reservoirs are in closed anticlinal structures—for example, in the Salem, Louden, and Lawrence fields. Many oil reservoirs in Illinois are sand lenses, mostly on anticlines or their flanks. The widespread McClosky oolitic limestone oil production occurs in porosity lenses on regional anticlines—for example, in the Clay City Consolidated and Lawrence fields. There are many faulted reservoirs, especially in the lower Wabash River region.

The control of oil occurrence by facies is important in Illinois, and facies studies are receiving more and more attention as an aid in oil exploration. It may well be that the major structural accumulations of oil in Illinois have all been discovered, but it seems likely that many stratigraphic traps remain to be found.

Exploration Methods

Both geological and geophysical investigations have contributed greatly to successful exploration for oil in Illinois. Mapping bedrock structure by surface studies is handicapped by the cover of glacial drift in most of the state. Only a few of the known oil-bearing structures are evident at the surface; examples are the Waterloo and Dupo structures, which are local closures on a continuous anticline.

When the reflection seismograph method was introduced in Illinois in 1935, it immediately achieved spectacular results in discovering the Clay City and Salem-Louden anticlines. Many other successes attended the use of the seismograph, but in recent years its use has been declining in Illinois because, in general, the difficulty of finding oil-bearing structures becomes greater the smaller the structural features being sought. Refinements in instruments and procedure and in the interpretation of results, however, may cause the seismograph method to be used for a long time.

Other geophysical methods used in Illinois include gravity, magnetic, and radioactivity surveys. Use of the scintillometer to aid in oil exploration has been reported outside Illinois, but whether it will prove successful here remains to be seen.

Aids to Production

The oldest aid to production of Illinois wells is nitroglycerin shooting. Acidizing of limestone pays began in Illinois about 1935 and has been extensively used. Hydraulic fracture treatment of sandstone pays began in Illinois about three years ago and was later extended to limestone pays. In 1954 about 70 per cent of the producing wells completed in Illinois were fracture-treated. Secondary recovery of oil, especially by waterflooding, has

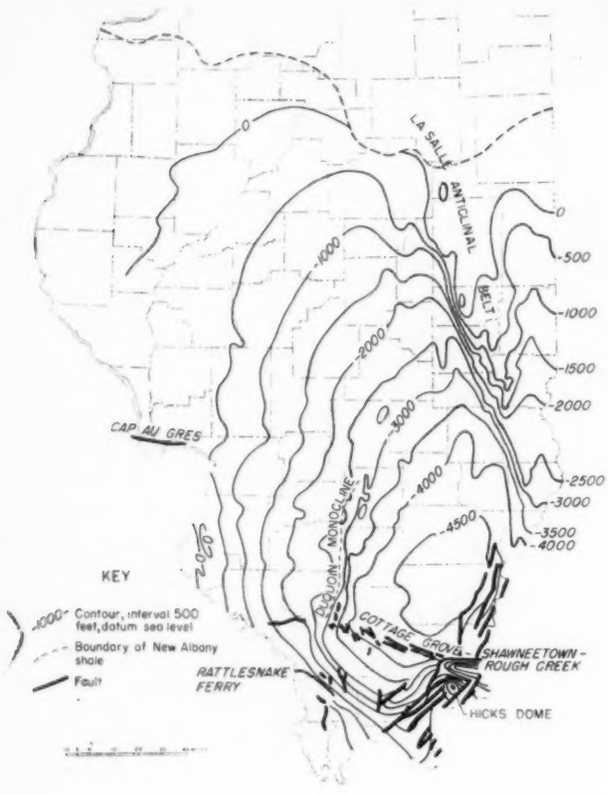
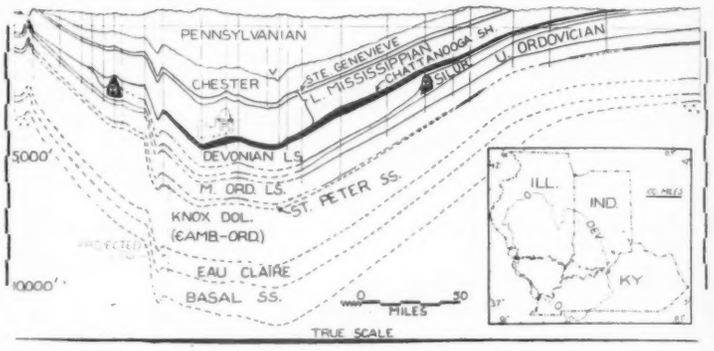


FIG. 5. Structure of base of New Albany shale in central and southern Illinois.

FIG. 6. Cross section of Eastern Interior basin. The letter "R" stands for reef. (After Illinois State Geological Survey Circular 169 (1951), "Future Oil Possibilities of the Eastern Interior Basin," by David H. Swann and others. Reprinted from the Eastern Interior Basin Chapter "Possible Future Petroleum Provinces of North America," AAPG Bulletin 1951, Fig. 147, p. 488.)



increased each year. In 1954 it is estimated to have contributed approximately 27 per cent of the state's total. Secondary recovery in Illinois was discussed in an article in *The Petroleum Engineer* for April 1954.*

Pipe Lines and Refineries

The principal trunk pipe lines in Illinois are shown in Fig. 7 (crude oil), 8 (natural gas), and 9 (refined products). Several of the pipe lines shown carry oil and gas from other states into or through Illinois. The locations of two underground storages of natural gas in porous sandstone reservoirs, at Waterloo and Herscher, are shown, as are the locations of four mined caverns for the storage of liquid propane, at Eola, Kankakee, Tuscola, and Crossville. The locations of refineries in Illinois and just outside the state boundary are shown. These, with their capacities, are given in Table 1.

Natural Gas

Natural gas has always been a minor economic product in Illinois in comparison with oil. Nearly all the natural gas obtained is solution gas produced with oil. The total of this gas in 1954 is estimated at 20 billion cubic feet. Gas has been marketed from a number of gas pools in the past, but in 1954 the only gas marketed for use away from producing areas was from the Harrisburg and Herald Consolidated pools, both in the White-Gallatin-Saline counties area. The total of this gas was approximately 175 million cubic feet in 1954, with an estimated value at the wells of $17,500.

Natural Gasoline and Allied Products

Three major producers extracted a total of approximately 677,000 bbl of natural gasoline and 1,410,000 bbl of liquefied petroleum gases from 7756 million cubic feet of natural gas from Illinois wells in 1954.

The state totals for these products are not known but are no doubt considerably higher than those given here, which do not include the amounts produced from one major plant using gas from outside Illinois and several minor plants using Illinois gas. It is estimated that between 1 and 2 billion cubic feet of residue gas from extraction plants was reinjected into producing formations to aid in the production of oil.

TABLE 1. Oil refineries.

Company	City	Crude oil capacity, B/D
Advance Refining Co.	Centralia	3,000
Ashland Oil and Refining Co.*	St. Elmo	4,000
Calumet Refining Co.	Burnham	1,000
Clark Oil and Refining Corp.	Blue Island	20,000
Cross, Henry H. Co., Inc.	Colmar	1,000
Dupo Oil Refining Co.	Dupo	1,000
Hi-Power Oil Refining Co.	Salem	1,000
Ohio Oil Co.	Robinson	40,000
Pana Refining Co.	Pana	6,000
Pure Oil Co.	Lemont	45,000
Shell Oil Co.	Wood River	170,000
Sinclair Refining Co.	Hartford	28,000
Socony-Vacuum Oil Co., Inc.	East St. Louis	42,000
Standard Oil (Indiana)	Wood River	50,000
The Texas Co.	Lawrenceville	50,000
The Texas Co.	Lockport	65,000
Wireback, B. F.	Colmar	500

* Shut down January 1955.

Economic Data

The estimated value at the wells of the oil produced in Illinois in 1954 (66.9 million barrels) is $200,000,000; an average price per barrel of approximately $3.00. Price for most of the oil produced in 1954 was $3.02, but reductions toward the end of the year to $2.95 and $2.90 by various companies brought the average down slightly. There have been no significant price changes since the beginning of 1955.

Estimated value at the plants of nat-

TABLE 2. Major natural gasoline plants.

Company	Location	County	Field
Carter Oil Co.	NW 15-8N-3E	Fayette	Louden
Carter Oil Co.	SW 33-8N-3E	Fayette	Louden
The Texas Co.	SW 11-6-S-6E	Hamilton	Dale Consol.
The Texas Co.	SE 32-2N-2E	Marion	Salem
Warren Petroleum Co.	NW 20-4S-14W	White	New Harmony

*Witherspoon, P. A., Flooding Can Recover 800 Million Additional Barrels of Oil: *The Petroleum Engineer*, p. B-40-B-52, April 1954.

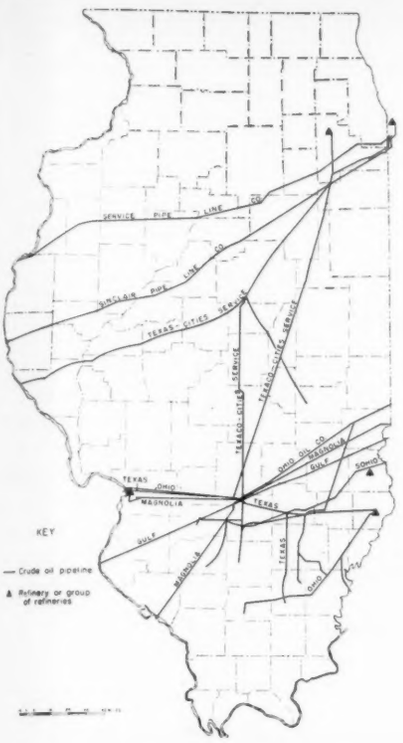


FIG. 7. Principal crude oil pipe lines and refineries, January 1, 1955.

FIG. 8. Principal natural gas pipe lines and underground storage locations, January 1, 1955.

FIG. 9. Principal products pipe lines, and underground storage of liquid propane in mined caverns, January 1, 1955.

ural gasoline and liquefied petroleum gases produced from Illinois natural gas in 1954 is $5,000,000.

Developments in 1955

Drilling in the first 5 months of 1955 continued at the high rate established in 1954, when total drilling was up 50 per cent from 1953. The most noteworthy development was the drilling of about 100 wells in the Eldorado pool, Saline County, between December 1, 1954, and May 31, 1955, most of which produce from a long narrow lens of Waltersburg sandstone, which appears to have been deposited as an offshore bar. Pay thickness varies from nothing at the edges up to as much as 60 ft in the middle. Many wells had initial oil productions from 1000 up to 4000 bbl. Large quantities of gas produced with the oil are almost entirely flared.

The estimated total daily rate of gas production for the Eldorado field was 55 million cubic feet on March 2, 1955, and 36 million cubic feet on May 25, 1955. Oil production was estimated at 20,000 bbl per day at the end of May. The Eldorado field has been a principal factor in the state's increase in production in 1955.

TABLE 3. Pipe line companies.

CRUDE OIL
Ashland Oil and Transportation Co., Ashland, Ky.
Farm Bureau Oil Co., Inc., Mt. Vernon, Ind.
Gulf Pipe Line Co., Tulsa, Okla.
Interstate Pipe Line Co., Tulsa 2, Okla.
Loudon Pipeline Co., Pana, Ill.
Magnolia Pipe Line Co., Box 900, Dallas 1, Texas
The Ohio Oil Co., Findlay, Ohio
The Pure Oil Co., 35 E. Wacker Drive, Chicago, Ill.
Pure Transportation Co., 35 E. Wacker Drive, Chicago, Ill.
Service Pipe Line Co., Tulsa, Okla.
Shell Oil Co., Inc., 50 West 50th St., New York 20, N.Y.
Shell Pipe Line Corp., 50 West 50th St., New York 20, N.Y.
Sinclair Pipe Line Co., Independence, Kansas
Sohio Pipe Line Co., 407 N. 8th St., St. Louis 1, Mo.
Sun Oil Co., Philadelphia, Pa.
The Superior Oil Co., Crossville, Ill.
Texaco-Cities Service Pipe Line Co., Tulsa, Okla.
The Texas Pipe Line Co., Houston 1, Texas
The Toronto Pipe Line Co., Philtower Bldg., Tulsa, Okla.

PRODUCTS
Badger Pipe Line Co., Bartlesville, Okla.
Buckeye Pipe Line Co., Findlay, Ohio
Great Lakes Pipe Line Co., Box 2239, Kansas City, Mo.
The Ohio Oil Co., Findlay, Ohio
Phillips Petroleum Co., Bartlesville, Okla.
Shell Pipe Line Corp., 50 West 50th St., New York 20, N.Y.
Sinclair Pipe Line Co., Independence, Kansas
Standard Oil Co. (Ind.), 910 S. Michigan Ave., Chicago, Ill.
The Texas Pipe Line Co., Houston 1, Texas

NATURAL GAS
Allied Gas Co., Paxton, Ill.
Cairo Public Utility Commission, Cairo, Ill.
Central Illinois Electric and Gas Co., 301 N. Main St., Rockford, Ill.
Central Illinois Light Co., 316 S. Jefferson Ave., Peoria, Ill.
Central Illinois Public Service Co., Illinois Building, Springfield, Ill.
Chicago District Pipeline Co., Joliet, Ill.
Citizens Gas Co., Tuscola, Ill.
Crawford County Gas Co., Sullivan, Ind.
Fairfield Municipal Gas, Fairfield, Ill.
Illinois Electric and Gas Co., Murphysboro, Ill.
Illinois Gas Co., Olney, Ill.
Illinois Power Co., 134 E. Main St., Decatur, Ill.
Interstate Power Co., Clinton, Iowa
Iowa-Illinois Gas and Electric Co., Rock Island, Ill.
Michigan Wisconsin Pipe Line Co., Detroit 26, Mich.
Mississippi River Fuel Corp., 407 N. 8th St., St. Louis 1, Mo.
Monarch Gas Co., St. Elmo, Ill.
Natural Gas Pipeline Co. of America, 20 N. Wacker Dr. Chicago, Ill.
North Shore Gas Co., Waukegan, Ill.
Northern Illinois Gas Co., 615 Eastern Ave., Bellwood, Ill.
Panhandle Eastern Pipe Line Co., 1221 Baltimore Ave., Kansas City, Mo.
Salem Municipal Gas, Salem, Ill.
South Beloit Water, Gas and Electric Co., South Beloit, Ill.
Texas Eastern Transmission Corp., Shreveport, La
Texas Gas Transmission Corp., Owensboro, Ky.
Texas Illinois Natural Gas Pipe Line Co., 20 N. Wacker Drive, Chicago, Ill.
Trunkline Gas Co., Houston, Texas
V. M. Pipeline Co., Vandalia, Ill.
Wabash Natural Gas Co., Carmi, Ill.

Outlook for the Future

Illinois may be expected to continue finding and producing oil for many years. As indicated above, oil reservoirs found in the future may be expected to be mainly stratigraphic rather than structural. Refinements in exploratory methods may lessen somewhat the difficulty of finding stratigraphic traps. There is opportunity for a much greater use of subsurface geology in exploring for oil in Illinois.

Much of the emphasis in the past has been on structural studies, with only such attention to stratigraphic problems as was necessary to determine structure. The emphasis will probably shift increasingly to studies of sedimentary petrology, facies, paleoecology, and paleogeography. I believe that such studies will be most useful in the search for new oil reserves. * *

Six-Point Program Will Improve

MANAGEMENT—EMPLOYEE RELATIONS

Ray O. Weems, Jr.

FOR many people in the oil industry, the term "Industrial Relations" has a somewhat vague and nebulous connotation. It is often thought of as some kind of new development having to do with labor unions or perhaps a fancy way to figure out which man to hire and where to place him. To some, it is a newfangled idea which means that the boss ought to take time away from his busy day to stick his nose in the hands' personal lives and be sure to smile, be friendly, and say "howdy" at least once a day. To a considerable number of old-timers, it's a couple of dirty words meaning that you can't just up and fire a guy like you could in the old days.

Actually, industrial or employee relations is nothing new; the present day approach, thought by many to be new, is the result of a slow but steady change in method as dictated by changing times on the industrial scene. When recognized as covering all aspects of the relationship between management and employees, it is obvious that industrial relations has been practiced in the oil industry from the time the first company was organized.

Development

Recognition of the importance of factors other than wages when considering this employee relationship became evident in the oil industry in the early 1900's. This was due, undoubtedly, to increased labor union activity and the industry's accelerated growth during the period.

Initially, this consideration resulted in the "welfare" or paternalistic approach later augmented by installation of benefit plans. These plans are, of course, a segment of any company's industrial relations program. They serve to relieve the employee of concern for his and his family's economic security. They do not, however, alone insure good employee relations nor deter an employee from changing jobs within the industry since practically all of the larger companies and many of the smaller ones offer similar benefits.

In more recent years, managements of progressive companies have found that good employee relations require something other than paternalism and the purchase of group insurance and annuities. They have found that reasonable personnel policies administered consistently, good supervision, properly aligned salaries and wages, and active two-way communications will

EXCLUSIVE

answer the employee's desire for fair treatment, recognition, and an understanding of his opportunities. They have found that these desires rank along with and frequently above wages in the employee's evaluation of his company as an employer. They have also found that line management must give employee relations the same day-to-day attention it gives exploration, production, and sales.

A great deal of credit for the now well-accepted principles of sound employee relations as a management function and industrial relations as a specialized field can be attributed to eastern industrial relations consulting organizations, the first one having been established some twenty-nine years ago. Having viewed, as outsiders, the personnel practices of companies in various industries, they could observe, objectively, the weakness of the "welfare" approach and the need for programs to neutralize excessive turnover, absenteeism, and employee discontent. Once appreciating the value of a positive approach to the problem, many of the larger companies retained these organizations to survey this personnel practices and to advise them on what was needed in the way of a program and how to develop a department to help management carry out that program. As a direct result of this guidance, some companies have established departments, staffed with specialized industrial relations personnel, that have assisted their managements in the development and maintenance of sound employee relations programs. Through their constant research and attention aimed at continued improvement of policies and practices, the larger companies have avoided excessive turnover and absenteeism, difficulties under governmental wage controls and wage-hour regulations, general employee discontent, and, with few exceptions, prolonged strikes. The absence of these factors plus the decrease in accident costs through safety training have more than justified the cost of these staff departments.

Smaller companies, whose size do not warrant integrated industrial relations departments, have also found consultants' services invaluable in objectively surveying their practices, outlining programs, and assisting them in carrying out these programs without additions to their staffs.

Smaller Companies

The need for a positive approach to industrial relations is, if anything, even greater in the smaller companies, where indifferent or poor employee relations may have a considerable influence on a company's chances for continued growth and expansion. In this connection, managements of smaller companies are frequently inclined to overlook the fact that their relations with office, technical, and sales personnel are just as important as their relations with field personnel. The loss of sales and the high cost of operating may very easily be due to poor initial selection, lack of enthusiasm and efficiency, discontent, and excessive turnover in the white-collar groups.

A mistake made by some companies in the oil industry is to consider their employee relations obligation discharged by the payment of top wages and salaries and the establishment of liberal benefit plans. While this has some public relations and recruitment appeal, it has very little long-range bearing on the attitude of employees generally toward their company and their work. High pay and liberal benefits are not a substitute for sound day-to-day employee relations practices. By the same token, certain "frills" such as the year-end bonus, parties for employees, Christmas gifts, educational assistance, and a company magazine will not buy a good relationship. Some or all of these actions may be beneficial to the company, but it is a mistake merely to assume so without taking the trouble to find out what the company is actually buying with the dollars spent on such projects.

The adoption of time-tested principles by the smaller companies can be accomplished internally with little expense but great return once their managements recognize the need for constant attention to employee relations by all levels of supervision.

The Author

Ray O. Weems, Jr., a partner in the industrial relations services firm of Weems and Neptune, Houston, Texas, was formerly division industrial relations supervisor for Stanolind Oil and Gas Company's Texas-Louisiana Gulf Coast division. A graduate of the University of Oklahoma in 1943, Weems was with Stanolind for nine years prior to the organization of the services firm.

Sound Principles

The goals of a sound employee relations program should be to develop the people in an organization into a better working team and to develop an attitude in the work force that is compatible with the objectives of management. In working toward these goals, there are a number of actions that the management of a company, regardless of size, can take.

1. Management can establish a selection procedure that will eliminate most of the mistakes made in hiring.

Providing proper training and guidance for all supervisors concerned with the interviewing and hiring process is important. In cases where seniority has a role in promotions, either by company policy or by collective bargaining agreement, it becomes essential to give particular attention to a job applicant's potentialities. In many cases, the establishment of an effective policy of promotion from within has been prevented due to the failure to hire into the lower level jobs individuals capable of being trained for advancement.

2. Management can establish induction, development, and communications systems that will enhance the loyalty, enthusiasm, and efficiency of employees.

Proper induction will get the new employee started in the right way. The new employee wants to know more than merely what he is to do on the job. He is interested in the objectives, problems, history, policies, and organization of the company. The employee with this information will be a better employee. The time taken to insure a clear, systematic presentation of this information is time well spent.

Employee and supervisor development is the life blood of continuity of organization. A company's capacity to grow or to improve its operations and services is directly influenced by how well it develops the skills and attitudes of its people. There is something basically wrong in the organization that frequently finds itself unable to fill a higher job from within its own ranks.

Induction and development are segments of the much broader field of communications. "Communications" as used here means simply the furnishing of information to employees by management and the furnishing of information to management by employees. Despite the great amount of research that has been done in the general field of communications in industry, no set pattern has yet been established for the development of effective two-way communications.

Written matter such as employee handbooks, use of bulletin boards, the company house organ, and letters to employees from executives are fairly common examples of management efforts to establish downward communications. Too many managements, how-

over, blandly assume that the written word will get the job done and forget the fact that employees can't talk back to a piece of paper. Failure to equip supervisors with the advance additional information necessary to answer employees' questions is common. It should be obvious that the desired effectiveness of written communications can be obtained only when supplemented by adequate oral communications. The employee looks to his immediate supervisor for information. It is good business to equip the supervisor to furnish that information.

Grievance procedures, meetings with employee groups, and employee opinion polls are examples of attempts to establish a flow of information upward from employees to management. These may be effective, but only when recognizing the real key to good upward communications as being a supervisory force trained to listen. If employees know they can approach their supervisors freely with questions, problems, and suggestions, the foundation for good upward communications is established.

3. Management can establish equitable internal salary and wage structures.

All too often salaries and wages have been set or changed in a haphazard manner with the result that, over a period of time, individual rates will be far out of line. Salaries of long-service employees will be out of proportion to those paid newer employees doing the same or very similar work. Wage rates for a few top hourly-rate classifications will be based on outside competitors rates with no consideration given to the internal relationship of those rates with lower rated jobs.

This type of salary and wage administration can only add to discontent among employees and create needless problems for management.

By establishing reasonable, progressive ranges for salaried classifications and defining, in general terms, the duties of each classification, salary administration can be consistent with the result that employees will know where they stand and what their opportunities are. Established ranges make it much easier to recognize meritorious work equitably where there has been no change in duties and to make promotional changes within the structure to recognize additional duties and responsibilities.

Within any group of hourly or wage-rate classifications, the rates should logically increase from the lowest to the highest in an orderly pattern designed to recognize additional skill and responsibility. The establishment of too few rates with a wide gap between the lower classifications and the top classifications will stifle enthusiasm in the lower groups since they will see very little opportunity for steadily increasing their individual rates.

As companies grow, more formalized alignment attained by job evaluation methods may be warranted. With or without job evaluation, however, properly aligned structures within a company are far more important to morale than consideration of how particular rates compare with those paid by other companies.

From management's standpoint, an additional and important reason for established policies is the ever-present possibility of renewal of federal controls over salaries and wages. These controls, in the past, had little effect on companies having written job descriptions and salary and wage policies in operation at the time controls were imposed.

4. Managements can establish safety educational programs that will promote the attitude of safety.

In the oil industry great progress has been made in removing the material hazards from work locations. With these safer working conditions and safer tools, companies' safety records have consistently improved. The best safety records, however, belong to the companies that have been successful in combating the human errors that cause accidents.

An unending program of safety education (using all available techniques and devices) aimed at establishing proper safety attitudes will improve morale and pay its own way by reducing accidents caused by human failures.

5. Management can establish systems to insure that company personnel policies are clearly understood and uniformly administered.

Well-defined personnel policies and procedures should be compiled in orderly fashion and made available to all levels of supervision. When policies are determined, they are of little value unless those persons responsible for day-to-day administration are thoroughly familiar with the provisions. In some instances, companies have greatly improved their supervisors' effectiveness by condensing policies into supervisors' handbooks and by supplementing this information with intensive training on how to administer the provisions. Also, employee handbooks containing explanations of important policies that concern employees as individuals will develop a clearer understanding of those policies.

6. Management can provide for periodic measurements of the accomplishments and effectiveness of various phases of the employee relations program.

The fact that the effectiveness of the program cannot be measured with complete accuracy in relation to dollars and cents should not preclude intelligent and systematic inquiry into the entire program from time to time. With the proper approach, reasonably accurate answers as to whether or not each phase of the program is worth what it is costing can be obtained. Periodic review also often will bring to light weaknesses in administration that contribute to the failure of a particular phase of the program to accomplish its purpose.

Labor Unions

The much publicized merger of the AFL and CIO will be consumated the latter part of this year. The unions have announced that the merger will make possible an intensive organizational program.

The oil industry may expect increased union activity since a large segment of the industry is not presently organized. The next few years will see the establishment of collective bargaining relationships in much of this unorganized portion of the industry.

This union activity, coupled with ever-increasing recognition of the importance of industrial relations, should see more and more attention given to this phase of the business. The presence or absence of a labor union in a company's operations, however, should not be the determining factor in the approach to employee relations. In either case, managements must strive for the increased efficiency and loyalty of the work force since the principles of sound employee relations apply with equal validity in units represented by collective bargaining agencies.

The oil industry has, in recent years, an enviable record among major industries for its safety achievements and lack of labor strife. The latter is due, in part, to the widely dispersed nature of oil operations and the one-time predominate but fast disappearing "rugged individualism" of the workers in the oil industry. Much of the credit for this labor peace, however, must go to the general good health of the industry, which has permitted it to attract high-grade people. Thus it has had a head start in the development of high-grade managements. These factors give it the most essential ingredients necessary to establish and maintain sound and peaceful employee-employer relationships. Few other industries have this ready-made opportunity. * * *

Exploration, Drilling, Producing

Formation Symposium

A two-day symposium on "Formation Evaluation" held October 27-28 at the University of Houston, will be sponsored by the Gulf Coast section, AIME, University of Houston Student Chapter of AIME and the university's department of petroleum engineering. The program includes 14 technical papers and an equipment display.

First day papers will include advantages of certain evaluation techniques together with limitations, and where applicable, examples using specific field studies. Typical well completion fluids will be discussed.

Topic of papers presented the second day will cover overall evaluation and will include methods other than logging. Papers will be presented on drilling, coring, testing, and recommended formation evaluation programs for specific areas.

General A. D. Bruce, University of Houston's president, will welcome the group, and John R. Suman, retired Standard of New Jersey vice president, will deliver the keynote address at the second session.

This is the second symposium of this type; the first, held in January, 1951, pertained to "Permanent-Type Well Completions." More than 1400 engineers and specialists attended, some coming from as far as South America and Canada.

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SDX Forms Department

Sunray Mid-Continent Oil Company has organized an evaluation department, separate and apart from the firm's exploration and production departments. Reserve and economic evaluation studies of new field discoveries, properties being developed and those considered for acquisition of the company will be carried on by the new department. Log analysis section of the department will also assist the exploration and production departments. The evaluation group will be directed by Dr. C. W. Ziemer, previously chief reservoir engineer in the SDX production department.

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Canadian Safety Grant

Saskatchewan Petroleum Industry Safety Association has received a $3500 cash grant by the Saskatchewan Workmen's Compensation Board to be used for promotion of accident prevention, safety, and first aid activities within the exploration and drilling phases of the industry. A proposal now being considered would use the fund for the purchase of mobile equipment for instruction and demonstration in the field to augment work of existing safety clinics and other first aid field activities.

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APCO Moves Offices

Anderson-Prichard Oil Corporation has announced transfer of its West Texas-New Mexico production headquarters from Hobbs, New Mexico, to Midland, Texas. In Hobbs since 1935, the office was moved to bring supervisory personnel nearer the center of operations. Similar offices have been relocated by several other companies operating in the Permian Basin.

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Anniversary Fete Set

Oilmen attending the thirty-sixth annual meeting of the Texas Mid-Continent Oil and Gas Association in Dallas, Texas, will celebrate the silver anniversary of the discovery of the East Texas field. Sessions for the two-day meet will begin October 3, with Al G. Hill acting as general chairman. James P. Gasser heads the reception committee and R. L. Foree will be vice chairman. Meetings are slated at the Baker Hotel.

Penncol Organized

Penncol Development Corporation, operating in the Rocky Mountain area, has been formed by the Oil City, Pennsylvania, oil and gas management firm of POGMA, Inc. The new firm has been formed for oil property management and engineering consulting operations, and will have offices in Denver and Brush, Colorado.

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Phillips Challenges Law

Phillips Petroleum Company has challenged the constitutionality of a recently enacted Oklahoma law requiring companies to sell natural gas for irrigation power to surface owners. Phillips' suit named the members of the Oklahoma Corporation Commission and 10 Oklahoma residents as defendants, pleading its case before a federal court in Oklahoma City.

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Royalty Owners Organize

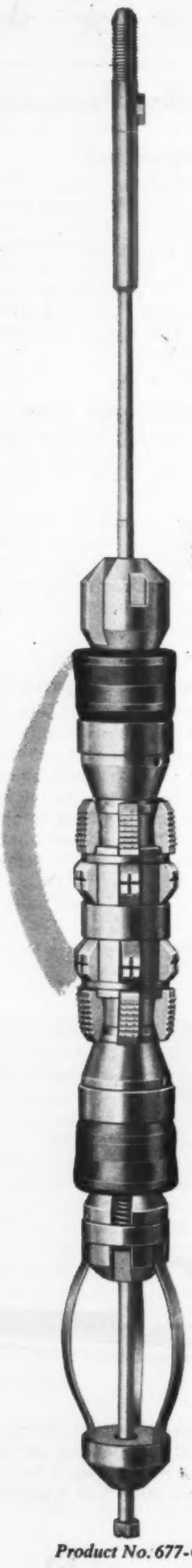
Grayson County Royalty Owners Association was organized recently by nearly 100 persons in the Sherman and Denison, Texas, area. An initial objective of the organization is to be the alteration of well spacing rules in the Grayson County oil development where geologic structure is known to be highly erratic.

Ada Oil Company's home office personnel will be housed in style at Houston's ultra-modern Adams Petroleum Center. The 20-story, $7,000,000 structure will be owned by K. S. Adams, president of Ada. Potential tenant of the building is Phillips Petroleum. Completion of the building, in the Shamrock-Hilton Hotel and Prudential Building area of Houston, is slated in about a year.

FRACTURE
ACIDIZE
SWAB *and* TEST

as many intervals as required

... in one round trip



Product No. 677-C

with BAKER RETRIEVABLE BRIDGE PLUG *and...*

SETS AND PACKS OFF AGAINST PRESSURE DIFFERENTIALS FROM EITHER ABOVE OR BELOW

After the Retrievable Bridge Plug has been run to the desired depth and released, it will automatically set and pack off against pressure differentials established from either above or below the tool.

CAN BE RUN IN AND RETRIEVED EASILY ... OR MOVED AND RESET AS MANY TIMES AS REQUIRED

The number of times that the Retrievable Bridge Plug can be released, moved and reset is limited only by the number or operations in the well that require its use.

NUMEROUS ECONOMICAL APPLICATIONS

Used WITH the Baker Full-Bore Retrievable Cementer for:

(a) *Straddle Operations*
The distance to be straddled is not limited by the made-up length of tool.

(b) *MULTIPLE Zone or Selective Testing, Fracturing, Acidizing*

Used BY ITSELF for:

(a) "Down-the-casing" Fracturing or Acidizing

(b) Testing operations

(c) Temporary pressure containment to permit repair to or removal of well head equipment with safety.

Write for Catalog Supplement No. 319 for complete information on

Another **PETROLEUM ENGINEER First**

DRILLING RIG LOCATOR

For the first time anywhere, current location, owner's name and address, type and size of more than 1700 contracting rigs are listed. Rigs shown here belong to 375 drilling contractors

Looking for a rig to drill a well in a particular area? You name the place, type and size of rig you need, and chances are you'll find the name and address of the contractor in THE PETROLEUM ENGINEER'S new, big, and first "Drilling Rig Locator" below. This is the first time such an attempt has been made to publish a directory of drilling rigs, including the contractor's name, address, type and size of equipment. Your editors realized that it would be next to impossible to obtain a complete list that would be current. However, after the last listing was made, it was felt that those contractors and the rigs shown here represent the bulk of the drilling industry.

Rigs are listed according to the state and county (or parish) in which they were working during the middle of August, 1955. There may be some movement from one county (or parish) to another, but, in the short time between gathering the information and publication date, this movement will not be significant. And, it was felt that most of the rig moves for the next several months will be within a given area or geologic province.

Contractor-owners were asked to rate their own rigs as to drilling depth, and no specifications for this rating were set forth. Some rated them for 4½ in. drill pipe; others used 3½ in. drill pipe. For this reason, there will be some discrepancies when horsepower ratings are considered. But, these two factors will enable the reader to judge the size of the rig listed. Horsepower on the drawworks for steam rigs was omitted for obvious reasons.

The Editors want to extend their heartiest thanks to those drilling contractors who willingly sent us the pertinent information. We will appreciate any comments as to how this drilling rig directory can be made more useful to the industry.

No concerted attempt was made to canvass the contractors in Canada. Since there was considerable response, those rigs on which data were supplied are listed.

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
ALABAMA			
Clark County			
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, gas-gaso	125	2500
Mobile County			
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas-diesel	1455	12,000
ARIZONA			
Navajo County			
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, gas-gaso	125	2500
ARKANSAS			
Bradley County			
Carter-Jones Drlg. Co.			
Box 1597, Kilgore, Texas	Rotary, gas-gaso	500	7000
Columbia County			
McAlester Fuel Co.			
Box 210, Magnolia, Ark.	Rotary, diesel	275	5500
	Rotary, butane-gas	820	11,000
Miller County			
Mercury Drlg. Corp.			
202 Continental Amer. Bk. Bldg.			
Shreveport, La.	Rotary, gas-gaso	150	4500
Saline County			
Walters Drlg. Co. Inc.			
4114 McMillan, Dallas, Texas	Rotary, gas	.....	600
	Rotary, gas	.....	600
	Rotary, gas	.....	300
	Rotary, gas	.....	900
	Rotary, gas	.....	600
Union County			
Alan Drlg. Co.			
820 O & G Bldg., Wichita Falls, Tex.	Rotary, gas-gaso	185	3500
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas diesel	1182	9000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
CALIFORNIA			
Fresno County			
Coalinga Drlg. Co.			
8845 West Olympic Blvd.,			
Beverly Hills, Calif.	Rotary	650	9000
Lebow Oil Co.			
8845 West Olympic Blvd.,			
Beverly Hills, Calif.	Rotary	650	9000
Newton Drlg. Co.			
Box 1104, Coalinga, Calif.	Rotary,diesel	600	8000
	Rotary, diesel	320	5000
Rocket Drlg. Co.			
2075 East 27th St., Long Beach, Calif.	Rotary, gas-gaso	350	7000
Kern County			
Douglas Drlg. Co.			
2509 Olympic Dr., Bakersfield, Calif.	Rotary, butane	125	2000
Drilling & Production Co.			
523 West Sixth, Los Angeles, Calif.	Rotary, diesel	420	6000
	Rotary,diesel, gas-gaso	432	6000
Green & Heiser Drlg. Co.			
Box 3098, Bakersfield, Calif.	Rotary, diesel	500	8000
	Rotary, diesel	500	8000
Hagestad Drlg. Co.			
3224 Gulf, Bakersfield, Calif.	Rotary, diesel	325	4500
	Rotary, diesel	460	8000
	Rotary, diesel	400	7000
Newton Drlg. Co.			
Box 1104. Coalinga, Calif.	Rotary, diesel	300	4000
Miller & York			
Box 936, Bakersfield, Calif.	Rotary, diesel	870	8500
	Rotary, diesel	550	5000
	Rotary, diesel	824	7000
Petrolex Inc.			
Box 53, Sta. B, Bakersfield, Calif.	Rotary, diesel	200	5000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Kings County			
Hagestad Drlg. Co.			
3224 Gulf, Bakersfield, Calif.	Rotary, diesel	400	7000
Los Angeles County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, diesel	350	4500
	Rotary, gas-gaso	450	6000
	Rotary, gas-gaso	500	7000
	Rotary, gas-gaso	900	9000
	Rotary, gas-gaso	600	7500
Drill. & Exp. Co. of Delaware, Inc.			
Box 2, Sta. H., Los Angeles 44, Calif.	Rotary, gas-gaso	900	12,500
International Drlg. Co.			
3040 Cherry Ave., Long Beach, Calif.	Rotary, gas-gaso	500	6000
	Rotary, gas-gaso	1200	12,500
	Rotary, diesel	1200	12,500
Fred Johnson Drlg. Co.			
2790 Cherry Ave., Long Beach, Calif.	Rotary, gas-gaso	700	10,000
	Rotary, gas-gaso	700	10,000
	Rotary, gas-gaso	700	6500
	Rotary, gas-gaso	1050	12,000
Miller & York			
Box 936, Bakersfield, Calif.	Rotary, diesel	550	5000
Terminal Drlg. & Production Co.			
1240 Blinn Ave., Wilmington, Calif.	Rotary, gas-gaso	105	2000
	Rotary, gas-gaso	440	7000
	Rotary, diesel	350	5000
	Rotary, gas-gaso	460	6000
	Rotary, diesel	350	5000
	Rotary, gas-gaso	440	7000
Wells Drlg. Co.			
5382 Cherry Ave., Long Beach, Calif.	Rotary, diesel	325	5000
	Rotary, diesel	325	5000
Monterey County			
Newton Drlg. Co.			
Box 1104, Coalinga, Calif.	Rotary, diesel	320	5000
Orange County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, gas-gaso	500	7000
	Rotary, gas-gaso	1050	12,000
Kee & Simpson Drlg. Co.			
417 S. Hill, Los Angeles, Calif.	Rotary, gas-butane	380	7000
	Rotary, gas-butane	380	7000
Miller & York			
Box 936, Bakersfield, Calif.	Rotary, diesel	550	5000
Ventura County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, gas-gaso	1350	12,000
Drill. & Exp. Co. of Delaware, Inc.			
Box 2, Sta. H, Los Angeles 44, Calif.	Rotary, steam	.....	18 000
	Rotary, steam	.....	18,000
	Rotary, gas-gaso	1200	18,000
	Rotary, gas-gaso	1200	18,000
	Rotary, gas-gaso	750	9000
	Rotary, gas-gaso	900	12,500
Terminal Drlg. & Production Co.			
1240 Blinn Ave., Wilmington, Calif.	Rotary, diesel	540	8000
	Rotary, diesel	350	5000
	Rotary, diesel	700	8500
United Drlg. Co.			
4310 Beverly Blvd., Los Angeles, Calif.	Rotary, gas	300	6000
COLORADO			
Adams County			
R. L. Manning Co.,			
318 Continental Bldg., Denver, Colo.	Rotary, gas-butane	450	6500
Crowley County			
Penrod Drlg. Co.,			
418 Market, Shreveport, La.	Rotary, diesel	730	9000
Dolores County			
Carmack Drlg. Co.			
1008 Mile High Center, Denver, Colo.	Rotary, diesel	680	8000
Julesburg Basin County			
Strain Drlg. Co.			
608 Patterson Bldg., Denver, Colo.	Rotary, diesel	600	7000
La Plata County			
Arapahoe Drlg. Co.			
504 Colorado Bldg., Denver, Colo.	Rotary, gas-gaso	600	8500
Fleeger-Riley Drlg. Co., Inc.			
271 Meadows Bldg., Dallas, Texas	Rotary, diesel	600	7500
Paul F. Rutledge			
Box 2239, Santa Fe, N. M.	Gas-gaso	600	7000
Larimer County			
J. D. Sprecher			
Box 299, Casper, Wyo.	Rotary, diesel	300	6500
Logan County			
Arapahoe Drlg. Co.			
504 Colorado Bldg., Denver, Colo.	Rotary, gas-gaso	300	5000
Brack Drlg. Co., Inc.			
Box 575, Fort Collins, Colo.	Rotary, diesel	606	8500
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, diesel	400	6000
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, gas-butane	290	6000
Don M. Rounds Drlg. Co.			
620 Colorado Bldg., Denver, Colo.	Rotary, diesel	500	7000
Mesa County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	750	8500
Moffat County			
Carmack Drlg. Co.			
1008 Mile High Center, Denver, Colo.	Rotary, gas-gaso	360	6500
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	800	7500
Rowan Drlg. Co., Inc.			
19th Fl., Fair Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1077	8500
Morgan County			
Carmack Drlg. Co.,			
1008 Mile High Center, Denver, Colo.	Rotary, diesel	360	6500
Cimarron Western Drlg. Co.			
722 Midland Savings Bldg.,			
Denver, Colo.	Rotary, gas-gaso	558	8000
Miracle-Fifer Drlg. Co.			
1636 Welton, Denver, Colo.	Rotary, butane	420	6000
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, diesel	700	10,000
Rio Blanco County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, gas-gaso	700	9000
	Rotary, gas-gaso	825	9000
Washington County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	260	6500
Geo. G. Johnson Drlg. Co.			
1104 Mile High Center, Denver, Colo.	Rotary, gas	400	6000
Don Johnston Drlg. Co.			
623 Empire Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	675	5000
	Rotary, diesel, gas-gaso	650	5000
Lohmann-Johnson Drlg. Co., Inc.			
320 Indiana Bank Bldg.,			
Eavnsville, Ind.	Rotary, diesel	440	5500
Signal Drilling Co.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, convertible	200	5000
Weld County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, gas-gaso	600	8000
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	520	9000
Colorado-Wyoming Drlg. Co.			
1119 Mile High Center, Denver, Colo.	Rotary, diesel	650	8000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	832	11,000
Don M. Rounds Drlg. Co.			
620 Colorado Bldg., Denver, Colo.	Rotary, diesel	600	10,000
Yuma County			
Zephyr Drlg. Corp.			
1111 First Natl. Bldg., Tulsa, Okla.	Rotary, steam	.....	7000
FLORIDA			
Jackson County			
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary,diesel	290	7500
Manatee County			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	900	12,500
Monroe County			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, diesel, barge	1500	15,000
Orange County			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	1200	15,000

ILLINOIS

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Bond County			
Troop Drlg. Co.			
Box 145, St. Elmo, Ill.	Rotary, gas-gaso	200	4500
Christian County			
C. W. Strotman Drlg. Co.			
620 S. 30th, Mattoon, Ill.	Cable tool, gas	145	3500
Clark County			
Claypool Drlg. Co.			
St. Elmo, Ill.	Cable tool, gas-gaso	65	1500
	Cable tool, gas-gaso	65	1500
Clay County			
D. B. Lesh Drlg. Co.			
Box 380, Mattoon, Ill.	Rotary, diesel	200	4000
Ted Lindsay			
Box 190, Mt. Vernon, Ill.	Rotary, diesel	300	4500
J. W. Rudy			
Box 684, Clay City, Ill.	Rotary, diesel	200	4500
	Rotary, diesel	310	6500
Don Slape Drlg. Co.			
Box 432, Olney, Ill.	Rotary, diesel	230	6500
Clinton County			
Canter Drlg. Co.			
833 Main, Mt. Vernon, Ill.	Rotary, gas-gaso	145	3000
Conrey Drlg. Co.			
328 E. Broadway, Centralia, Ill.	Rotary, diesel	200	2500
	Rotary, gas-gaso	170	2000
Crawford County			
Canter Drlg. Co.			
833 Main, Mt. Vernon, Ill.	Rotary, gas-gaso	115	2000
Dillier & Knierim			
Box 341, Casey, Ill.	Rotary, gas-gaso	130	2000
Walter L. Dillier			
Box 341, Casey, Ill.	Cable tool, gas-gaso	65	1500
Hoagland Drlg. Co., Inc.			
Robinson, Ill.	Rotary, gas-gaso	105	2000
Payne Brothers Drlg. Co.			
1411 10th St., Lawrenceville, Ill.	Cable tools, diesel	150	3500
Walton Drlg. Co.			
Fairfield, Ill.	Rotary, gas-gaso	136	2500
	Rotary, gas-gaso	136	2500
Edwards County			
Ardee Oil Co.			
2509 Washington Av., Evansville, Ind.	Rotary, diesel	1000	7500
The Noah Petroleum Co.			
Citizens Natl. Bk. Bldg., Albion, Ill.	Rotary, diesel	260	5500
Effingham County			
Dillier & Knierim			
Box 341, Casey, Ill.	Rotary, gas-gaso	212	3000
Fayette County			
Claypool Drlg. Co.			
St. Elmo, Ill.	Cable tool, gas-gaso	78	3500
	Cable tool, gas-gaso	78	3500
	Cable tool, gas-gaso	65	1500
	Cable tool, gas-gaso	65	1500
Donald P. Knierim			
Box 341, Casey, Ill.	Cable tool, gas-gaso	65	1500
	Cable tool, gas-gaso	65	1500
Franklin County			
C. E. Brehm Drlg. & Producing			
Box 368, Mt. Vernon, Ill.	Rotary, diesel	275	4500
	Cable tool, gas-gaso	184	5000
Gallatin County			
Claypool Drlg. Co.			
St. Elmo, Ill.	Rotary, gas-gaso	145	4500
Eakle & Holder Drlg. Co.			
116 Mulberry, Evansville, Ind.	Rotary, diesel	300	5500
Ervin Drlg. Co., Inc.			
Box 285, Salem, Ill.	Rotary, diesel	125	2500
Fortune Drlg. Corp.			
Box 140, Princeton, Ind.	Rotary, gas	276	3500
Kendall-Davis Drlg. Co., Inc.			
2374 Adams Ave., Evansville, Ind.	Rotary, diesel	170	4000
Goles County			
C. W. Strotman Drlg. Co.			
620 S. 30th St., Mattoon, Ill.	Cable tool, gas	145	3500
Hamilton County			
C. E. Brehm Drlg. & Producing			
Box 368, Mt. Vernon, Ill.	Cable tool, gas gaso	184	5000
General Geophysical Co.			
750 Houston Clb. Bldg., Houston, Tex.	Rotary, diesel	400	4500
Pep Drlg. Co.			
1008½ Main, Mt. Vernon, Ill.	Rotary, diesel	340	5500
C. W. Strotman Drlg. Co.			
620 S. 30th St., Mattoon, Ill.	Cable tool, gas	175	3500
Walter W. Willis			
813 Broadway, Mt. Vernon, Ill.	Rotary, diesel	270	6500
Jasper County			
D. B. Lesh Drlg. Co.			
Box 380, Mattoon, Ill.	Rotary, diesel	200	4000
Don Slape Drlg. Co.			
Box 432, Olney, Ill.	Rotary, diesel	230	4500
Jefferson County			
Ted Lindsay			
Box 190, Mt. Vernon, Ill.	Rotary, diesel	200	3500
	Rotary, gas-gaso	225	3500
B. L. Rucker			
Box 127, Mt. Vernon, Ill.	Rotary, diesel	320	6000
Lawrence County			
Central Drlg. Co.			
704 10th St., Lawrenceville, Ill.	Rotary, butane	140	2500
Dillier & Knierim			
Box 341, Casey, Ill.	Rotary, gas-gaso	130	2000
Harris Drlg. Co.			
Box 626, Grayville, Ill.	Rotary, butane	195	4000
Houchins Drlg. Co.			
Box 218, Mt. Carmel, Ill.	Rotary, gas	185	3500
	Cable tool, gas	140	3000
Nation Drlg. Co.			
Drawer 301, Fairfield, Ill.	Cable tool, gas-gaso	130	4000
	Rotary, diesel	220	4000
Payne Brothers Drlg. Co.			
1411 10th St., Lawrenceville, Ill.	Cable tools, diesel	150	3500
Don Slape Drlg. Co.			
Box 432, Olney, Ill.	Rotary, diesel	230	4500
U & E Drlg. Co.			
Sullivan, Ind.	Rotary, diesel	400	5000
Macon County			
Hinkle Drlg. Co.			
439 Standard Off. Bldg., Decatur, Ill.	Rotary, butane	165	3500
Madison County			
Perrine & Perrine Drlg.			
Box 87, Salem, Ill.	Rotary, butane	185	6000
Montgomery County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	190	5000
Pulaskir County			
Dee Watson Drlg. Co.			
Mt. Carmel, Ill.	Rotary, diesel	200	3600
Richland County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	260	5500
	Rotary, diesel	190	5000
Hupp & Hume			
Box 616, Owensboro, Ky.	Rotary, diesel	300	4500
D. B. Lesh Drlg. Co.			
Box 380, Mattoon, Ill.	Rotary, gas	450	7000
Olds Oil & Chemical Corp.			
Box 90, Mt. Carmel, Ill.	Rotary, butane	200	3500
Pep Drlg. Co.			
1008½ Main, Mt. Vernon, Ill.	Rotary, diesel	340	5500
Walter W. Willis			
813 Broadway, Mt. Vernon, Ill.	Rotary, diesel	270	6500
Saline County			
Big Seven Drlg. Co.			
311 Wright Bldg., Evansville, Ind.	Rotary, diesel	300	5000
C. E. Brehm Drlg. & Producing			
Box 368, Mt. Vernon, Ill.	Rotary, diesel	275	4500
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, gas-gaso	165	4500
Fortune Drlg. Corp.			
Box 140, Princeton, Ind.	Rotary, diesel	188	2300

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Gene Miller, Inc.			
Box 238, Lawrenceville, Ill.	Rotary, diesel	300	5000
Petro Drlg. Co., Inc.			
Box 339, Mt. Vernon, Ill.	Rotary, diesel	300	6500
U & E Drlg. Co.			
Sullivan, Ind.	Rotary, diesel	200	3500
Wabash County			
Ardee Oil Co.			
2509 Washington Av., Evansville, Ind.	Rotary, diesel	500	3500
Payne Brothers Drlg. Co.			
1411 10th St., Lawrenceville, Ill.	Cable tools, diesel	120	2500
Dee Watson Drlg. Co.			
Mt. Carmel, Ill.	Cable tool, gas-gaso	100	3600
	Cable tool, gas-gaso	100	3600
Washington County			
M. Majzarino			
Staunton, Ill.	Rotary, gas-gaso	200	2500
Wayne County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	190	5000
D. B. Lesh Drlg. Co.			
Box 380, Mattoon, Ill.	Rotary, diesel	320	5500
Dee Watson Drlg. Co.			
Mt. Carmel, Ill.	Rotary, diesel	165	3600
Nation Drlg. Co.			
Box 301, Fairfield, Ill.	Rotary, gas-gaso	190	4000
Paco Petroleum Corp.			
Box 347, Mt. Carmel, Ill.	Rotary, diesel	320	5500
White County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	260	5500
Ferbanta Drlg. Co.			
Box 107, Carmi, Ill.	Rotary, gas	215	5000
	Rotary, gas	180	4200
Harris Drlg. Co.			
Box 626, Grayville, Ill.	Rotary, butane	195	4000
Jack Hinkle			
208 N. Church, Carmi, Ill.	Rotary, gas-gaso	185	3300
	Rotary, gas-gaso	185	3300
	Cable tool, gas-gaso	145	3300
Olds Oil & Chemical Corp.			
Box 90, Mt. Carmel, Ill.	Rotary, butane	85	1500
Paco Petroleum Corp.			
Box 347, Mt. Carmel, Ill.	Rotary, diesel	4000	7000
Perrine & Perrine Drlg.			
Box 87, Salem, Ill.	Cable tool, butane	145	6000
Don Slape Drlg. Co.			
Box 432, Olney, Ill.	Rotary, diesel	230	6500
C. W. Strotman Drlg. Co.			
620 S. 30th St., Mattoon, Ill.	Cable tool, gas	145	3000
Walter W. Willis			
813 Broadway, Mt. Vernon, Ill.	Rotary, diesel	270	6500
INDIANA			
Gibson County			
Ardee Oil Co.			
2509 Washington Av., Evansville, Ind.	Cable tool, butane	145	5000
Bury Drlg. Co.			
Box 316, Princeton, Ind.	Rotary, diesel	250	3000
Highland Oil			
105 6th St., Jasper, Ind.	Cable tool, butane	85	1640
Olds Oil & Chemical Corp.			
Box 90, Mt. Carmel, Ill.	Cable tool, butane	140	4500
Paco Petroleum Corp.			
Box 347, Mt. Carmel, Ill.	Rotary, butane	200	4000
Princeton Mining Co.			
Terre Haute, Ind.	Cable tool, gas-gaso	110	3500
Henry M. Willis Drlg. Co.			
117½ N. Hart, Princeton, Ind.	Rotary, butane	110	2500
Pike County			
Henry Gwaltney Drlg. Co.			
State Bldg., Washington, Ind.	Rotary, diesel	200	3000
High'and Oil			
105 6th St., Jasper, Ind.	Cable tool, butane	65	970
Vigo County			
Dillier & Knierim			
Box 341, Casey, Ill.	Rotary, gas-gaso	130	2000
Washington County			
Tri-County Exploration Co., Inc.			
412 Peoples Bk. Bldg.,			
Indianapolis, Ind.	Rotary, gas-gaso	100	1200

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
KANSAS			
Barber County			
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, diesel	280	5500
Mobile Drlg. Co.			
705 4th Natl. Bk. Bldg., Wichita, Kan.	Cable tool, gas-gaso	225	7800
R. C. Patton Co.			
612 Orpheum Bldg., Wichita, Kan.	Rotary, gas-gaso	450	6500
	Cable tool, gas-gaso	400	6000
	Rotary, diesel	350	5500
Pickrell Drlg. Co.			
705 4th Natl. Bk. Bldg., Wichita, Kan.	Rotary, diesel	270	5000
Transit Corporation			
1516 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	250	5000
Barton County			
Buick Drlg., Inc.			
Box 331, St. John, Kan.	Rotary, diesel	300	5000
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
Reserve Drlg. Co., Inc.			
703 Union Natl. Bldg., Wichita, Kan.	Rotary, diesel	550	7500
Veeder Supply & Development Co.			
Box 201, Cherryvale, Kan.	Rotary, diesel	300	4000
Butler County			
Strait Drlg., Inc.			
Box 90, El Dorado, Kan.	Cable tool, gas-gaso	187	4000
Clark County			
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	700	7500
Unit Drlg. Co.			
200 N. Main, Bristow, Okla.	Rotary, diesel	600	6500
	Rotary, gas-gaso	900	8500
Cowley County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
Kriswell Drlg. Co.			
First Natl. Bk. Bldg., Winfield, Kan.	Rotary, diesel	280	5000
L. C. Smitherman Drlg. Co.			
Box 627, Augusta, Kan.	Rotary, diesel	265	5500
Crawford County			
Walters Drlg. Co., Inc.			
4114 McMillan, Dallas, Texas	Rotary, gas		800
	Rotary, gas		1200
Dickinson County			
Donald T. Ingling			
623 First Natl. Bldg., Wichita, Kan.	Rotary, gas-gaso	270	4000
Ellis County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
K & E Drlg., Inc.			
1006 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	300	5000
Veeder Supply & Development Co.			
Box 201, Cherryvale, Kan.	Rotary, diesel	335	5500
Ellsworth County			
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, diesel	280	5500
K & E Drlg., Inc.			
1006 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	300	5000
Graham County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
	Rotary, diesel	296	5000
Transit Corporation			
1516 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, butane	250	4500
Harper County			
Beardmore Drlg. Co.			
827 Beacon Bldg., Wichita, Kan.	Rotary, diesel	450	6000
Haskell County			
Helmerich & Payne, Inc.			
First Natl.. Bldg., Tulsa, Okla.	Cable tool, diesel	150	6000
	Rotary, gas-gaso	700	7500
Mead County			
Cree Drlg. Co., Inc.			
Hughes Bldg., Pampa, Texas	Rotary, gas	600	9000
	Rotary, gas	500	7500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Midwestern Drillers, Inc.			
Wright Bldg., Tulsa, Okla.	Rotary, diesel	450	6500
Nye & Snell Drlg. Co.			
260 Denver Club Bldg., Denver, Colo.	Rotary, gas-gaso	500	7000
Montgomery County			
Veeder Supply & Development Co.			
Box 201, Cherryvale, Kan.	Cable tool, diesel	100	3500
Morton County			
Reading & Bates, Inc.			
1502 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1200	10,000
Pawnee County			
D & M Drlg. Co., Inc.			
Box 247, Great Bend, Kan.	Rotary, gas-butane	250	5000
Harms-Burt Drlg. Co.			
510 Petroleum Bldg., Wichita, Kan.	Rotary, diesel	330	6000
Reno County			
Buick Drlg., Inc.			
Box 331, St. John, Kan.	Rotary, diesel	300	5000
Rooks County			
Transit Corporation			
1516 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	250	4500
Rush County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
Russell County			
Shelley-Miller Drlg., Inc.			
205 Miller Bldg., Wichita, Kan.	Rotary, diesel	300	5000
Sedgwick County			
Beardmore Drlg. Co.			
827 Beacon Bldg., Wichita, Kan.	Rotary, diesel	300	4000
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
Mobile Drlg. Co.			
705 4th Natl. Bk. Bldg., Wichita, Kan.	Cable tool, gas-gaso	175	6000
	Cable tool, gas-gaso	125	4500
Stafford County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	296	5000
Harms-Burt Drlg. Co.			
510 Petroleum Bldg., Wichita, Kan.	Rotary, diesel	260	5000
Rocket Drlg. Co., Inc.			
352 N. Broadway, Wichita, Kan.	Rotary, diesel	520	7500
Stanton County			
D & M Drlg. Co., Inc.			
Box 247, Great Bend, Kan.	Rotary, gas-butane	500	7500
Midwestern Drillers, Inc.			
Wright Bldg., Tulsa, Okla.	Rotary, diesel	450	6500
Sumner County			
Ainsworth, Inc.			
1002 Union Natl. Bk. Bldg.,			
Wichita, Kan.	Rotary, gaso	100	1500
Mallonee Drlg. Co., Inc.			
812 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	200	5000
L. C. Smitherman Drlg. Co.			
Box 627, Augusta, Kan.	Rotary, diesel	175	4500
	Rotary, butane	145	4000
	Cable tool, butane	135	4500
	Cable tool, butane	135	4500
Wallace County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	640	8500
Washington County			
Garvey Drlg. Co.			
311 E. 3rd St., Wichita, Kan.	Rotary, diesel	640	7500
KENTUCKY			
Daviess County			
Basin Drlg. Co., Inc.			
322 St. Ann, Owensboro, Ky.	Rotary, diesel	300	6500
Stouder Drlg. Co.			
208 SE Riverside Dr., Evansville, Ind.	Rotary, butane	200	4500
Henderson County			
Eakle & Holder Drlg. Co.			
116 Mulberry, Evansville, Ind.	Rotary, diesel	260	4500
Stouder Drlg. Co.			
208 SE Riverside Dr., Evansville, Ind.	Rotary, butane	200	3500
Hopkins County			
Riley Q. Gammon			
509 N. Railroad, Madisonville, Ky.	Cable tool, diesel	65	1000
	Cable tool, gas-gaso	45	500
	Rotary, gas-gaso	90	2000
Mulenberg County			
Hupp & Hume			
Box 616, Owensboro, Ky.	Rotary, diesel	300	4500
Jack & H. P. Read			
Scottsville, Ky.	Cable tool, propane	78	3500
	Cable tool, gaso	65	1200
Marhill Oil & Gas Co., Inc.			
322 St. Ann, Owensboro, Ky.	Cable tool, gas-gaso	145	6000
Todd County			
Jack & H. P. Read			
Scottsville, Ky.	Cable tool, propane	175	4500
Union County			
Basin Drlg. Co., Inc.			
322 St. Ann, Owensboro, Ky.	Rotary, diesel	300	6500
LOUISIANA			
Acadia Parish			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, steam		12,000
	Rotary, diesel	700	11,000
Bullard Drlg. Co., Inc.			
1817 Melrose Bldg., Houston, Texas	Rotary, steam	1200	15,000
Circle Drlg. Co., Inc.			
620 Pioneer Bldg., Lake Charles, La.	Rotary, gas or butane	800	11,000
Clegg & Hunt			
715 Houston Club Bldg., Houston, Tex.	Rotary, diesel	1275	18,000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, steam	1135	15,000
Frawley Drlg. Co.			
823 S. Detroit, Tulsa, Okla.	Rotary, steam	1200	13,500
Mac Drlg Co.			
Box 2972, Houston, Texas	Rotary, steam		15,000
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, gas-gaso	312	8000
Win Hawkins Drlg. Co.			
373 San Jacinto Bldg., Houston, Texas	Rotary, steam		15,000
	Rotary, steam		15,000
Allen Parish			
Pernie Bailey Drlg. Contr.			
2309 Sage Rd., Houston, Texas	Rotary, gas-gaso	550	8000
Assumption Parish			
Circle Drlg. Co., Inc.			
620 Pioneer Bldg., Lake Charles, La.	Rotary, gas or butane	900	11,000
Gracey-Hellums Corp.			
1832 Commerce Bldg., Houston, Texas	Rotary, steam		15,000
Baton Rouge Parish			
Bateman Drlg. Co.			
601 Texas Co. Bldg., New Orleans, La.	Rotary, steam		14,000
Beauregard Parish			
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas or butane	580	8000
	Rotary, diesel	730	9000
Bienville Parish			
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, steam		12,000
Bossier Parish			
The H & S Drlg. Co.			
407 Tri State Ins. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1000	12,000
	Rotary, gas-gaso	1000	11,000
Caddo Parish			
B. F. Edingson Drlg. Co., Inc.			
Shreveport, La.	Rotary, gas-gaso	250	2500
	Rotary, gas-gaso	100	750
Gary Drlg. Co.			
Box 58, Oil City, La.	Rotary, butane	90	2000
	Rotary, butane	118	4000
Ed E. Hurley, Successors,			
Petroleum Bldg., Shreveport, La.	Rotary, gas-gaso	450	7000
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, gas-butane	1500	15,000
Tex-Mex Drlg. Co.			
1211 Fidelity Union Life Bldg.,			
Dallas, Texas	Rotary, gas-gaso	600	9000
	Rotary, gas-gaso	600	8000
	Rotary, steam		10,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	818	9500
Calcasieu Parish			
Harry L. Edwards Drlg. Co.			
Box 6825, Houston, Texas	Rotary, steam		15,000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, gas-gaso	.....	3000
Cameron Parish (Offshore)			
Circle Drlg. Co., Inc.			
620 Pioneer Bldg., Lake Charles, La.	Rotary, gas or butane	1400	15,000
Harry L. Edwards Drlg. Co.			
Box 6825, Houston, Texas	Rotary, steam	.....	15,000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	2300	20,000
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth, Texas	Rotary, diesel	1305	15,000
Salt Dome Production Co.			
1900 Mellie Esperson Bldg.,			
Houston, Texas	Rotary, diesel	1500	18,000
Win Hawkins Drlg. Co.			
373 San Jacinto Bldg., Houston, Texas	Rotary, steam	.....	15,000
Catahoula Parish			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	600	7500
Claiborne Parish			
Drilling & Exploration Co. of Delaware, Inc.			
227 Johnson Bldg., Shreveport, La.	Rotary, steam	.....	17,000
	Rotary, steam	.....	13,000
	Rotary, steam	.....	13,000
	Rotary, gas-gaso	200	2000
Maritzky & Bibby			
Homer, La.	Cable tool, gas-gaso	145	5000
	Rotary, gas-gaso	185	5000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	855	10,500
Concordia Parish			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	600	7500
Jett Drlg. Co., Inc.			
320 Johnson Bldg., Shreveport, La.	Rotary, diesel	600	7500
	Rotary, diesel	600	7500
	Rotary, diesel	700	9000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	385	6000
Petersen Petroleum Corp.			
306 Fairfield Bldg., Shreveport, La.	Rotary, gas-gaso	375	7000
Iberia Parish			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	900	12,500
Harry L. Edwards Drlg. Co.			
Box 6825, Houston, Texas	Rotary, diesel	1040	15,000
Falcon Seaboard Drlg. Co.			
Stanolind Bldg., Tulsa, Okla.	Rotary, steam	.....	20,000
	Rotary, steam	.....	20,000
	Rotary, steam	.....	20,000
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1680	15,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	1227	12,000
	Rotary, steam	.....	11,000
Iberville Parish			
Hawkins-Wilkins Production Co.			
373 San Jacinto Bldg., Houston, Texas	Rotary, steam	.....	15,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	730	9000
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth, Texas	Rotary, diesel, barge	2705	18,000
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, steam	724	12,000
Jefferson Parish			
Bateman Drlg. Co.			
601 Texas Co. Bldg., New Orleans, La.	Rotary, diesel	1000	18,000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	1800	15,000
Jefferson Parish (Offshore)			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, diesel	900	14,000
	Rotary, diesel	900	15,000
	Rotary, diesel	900	15,000
Jefferson Davis Parish			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, steam	.....	15,000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	800	9000
Harry L. Edwards Drlg. Co.			
Box 6825, Houston, Texas	Rotary, steam	.....	15,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	1095	11,000
	Rotary, diesel	730	9000
Prince Drlg. Co.			
1605 Bk. of Com. Bldg., Houston, Tex.	Rotary, steam	1400	15,000
Steen Drlg. Co.			
604 West Bldg., Houston, Texas	Rotary, steam	.....	16,000
C. B. Webster Drlg. Co.			
609 San Jacinto Bldg., Houston, Tex.	Rotary, steam	.....	15,000
	Rotary, steam	.....	15,000
Win Hawkins Drlg. Co.			
373 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	650	9000
Lafayette Parish			
Falcon Seaboard Drlg. Co.			
Stanolind Bldg., Tulsa, Okla.	Rotary, steam	.....	20,000
	Rotary, steam	.....	20,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, steam	.....	15,000
	Rotary, gas or butane	580	7000
Lafourche Parish			
B & G Drlg. Co., Inc.			
Box 277, Lockport, La.	Rotary, gas	375	6000
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, diesel, barge	1000	15,000
Circle Drlg. Co., Inc.			
620 Pioneer Bldg., Lake Charles, La.	Rotary, gas or butane	1440	15,000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, steam	1135	15,000
Harry L. Edwards Drlg. Co.			
Box 6825, Houston, Texas	Rotary, steam	.....	15,000
Salt Dome Production Co.			
1900 Mellie Esperson Bldg.,			
Houston, Texas	Rotary, diesel	1200	14,000
Southern Six Drlg. Co., Inc.			
Box 369, Opelousas, La.	Rotary, steam	.....	14,000
T-W Drlg. Co.			
542 Natl. Bk. of Commerce Bldg.,			
New Orleans, La.	Rotary, diesel	1500	17,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, steam	.....	15,000
	Rotary, diesel	1380	16,000
	Rotary, butane-gas	1305	13,500
Lincoln Parish			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	840	10,000
	Rotary, gas-gaso	840	10,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	450	7500
	Rotary, butane-gas	450	8500
Madison Parish			
Jett Drlg. Co., Inc.			
320 Johnson Bldg., Shreveport, La.	Rotary, diesel	1100	13,000
Marion Parish			
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	450	7500
Ouachita Parish			
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas-diesel	1455	11,000
Plaquemines Parish			
Bateman Drlg. Co.			
601 Tex. Co. Bldg., New Orleans, La.	Rotary, diesel	800	15,000
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary-barge, diesel	785	11,000
Gracey-Hellums Corp.			
1832 Commerce Bldg., Houston, Texas	Rotary, steam	.....	14,000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	2100	16,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	1095	12,000
Prince Drlg. Co.			
1605 Bk. of Com. Bldg., Houston, Tex.	Rotary, diesel	1100	15,000
	Rotary, diesel	1600	20,000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth, Texas	Rotary, diesel, barge	2800	18,000
	Rotary, diesel, barge	2700	18,000
	Rotary, diesel, barge	2325	18,000
	Rotary, steam, barge	750	18,000
T-W Drlg. Co.			
542 Natl. Bk. of Commerce Bldg.,			
New Orleans, La.	Rotary, steam	1500	17,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, steam		12,000
Win Hawkins Drlg. Co.			
373 San Jacinto Bldg., Houston, Tex.	Rotary, diesel	1000	14,000
Saline Parish			
B. F. Edingson Drlg. Co., Inc.			
Shreveport, La.	Rotary, gas-gaso	180	1500
St. Charles Parish			
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, steam		15,000
St. James Parish			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	900	15,000
Ed E. Hurley, Successors			
Petroleum Bldg., Shreveport, La.	Rotary, gas-gaso	1050	12,500
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, gas-gaso		14,000
St. John Parish			
Circle Drlg. Co., Inc.			
620 Pioneer Bldg., Lake Charles, La.	Rotary, gas or butane	960	11,000
St. Landry Parish			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, steam	1135	14,000
The Grey Wolf Drlg. Co.			
1405 S. Coast Life Bldg., Houston, Tex.	Rotary, gas-gaso	1125	12,000
	Rotary, steam		12,500
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	1000	12,500
St. Martin Parish			
B & G Drlg. Co., Inc.			
Box 277, Lockport, La.	Rotary, gas	785	12,000
Bullard Drlg. Co., Inc.			
1817 Melrose Bldg., Houston, Texas	Rotary, steam	1200	15,000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	1170	15,000
Harry L. Edwards Drlg. Co.			
Box 6825 Houston, Texas	Rotary, steam		15,000
Falcon Seaboard Drlg. Co.			
Stanolind Bldg., Tulsa, Okla.	Rotary, steam		20,000
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, steam		15,000
Steen Drlg. Co.			
604 West Bldg., Houston, Texas	Rotary, steam		16,000
C. B. Webster Drlg. Co.			
609 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	1250	15,000
	Rotary, steam		15,000
St. Mary Parish			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, diesel, barge	1500	15,000
	Rotary, diesel, barge	1500	15,000
Drilling & Exploration Co. of Delaware, Inc.			
227 Johnson Bldg., Shreveport, La.	Rotary, steam		17,000
	Rotary, steam		13,000
Falcon Seaboard Drlg. Co.			
Stanolind Bldg., Tulsa, Okla.	Rotary, steam		20,000
Kerr-McGee Oil Industries, Inc.			
306 N. Robinson,			
Oklahoma City, Okla.	Rotary, diesel	900	11,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas-gaso	1425	12,000
T-W Drlg. Co.			
542 Natl. Bk. of Commerce Bldg.,			
New Orleans, La.	Rotary, gas-gaso	1500	17,000
	Rotary, steam	1500	20,000
C. B. Webster Drlg. Co.			
609 San Jacinto Bldg., Houston, Tex.	Rotary, steam		15 000
	Rotary, steam		15,000
Wheless Drlg. Co.			
Box 368, Shreveport, La.	Rotary, butane-gas	1227	12,000
	Rotary, diesel	1380	16,000
Tensas Parish			
H. L. Rowley, Inc.			
Box 1784, Shreveport, La.	Rotary, diesel	800	12,000
	Rotary, diesel	500	8500
Jett Drlg. Co., Inc.			
320 Johnson Bldg., Shreveport, La.	Rotary, gas-gaso	80	9500
	Rotary, diesel	700	9000
Terrebonne Parish			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, diesel, barge	1500	15,000
	Rotary, diesel, barge	1500	15,000
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary-barge, gas-gaso	1260	15,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel electric	1500	18,000
	Rotary, gas or butane	1425	15,000
	Rotary, diesel	1200	12,000
Rowan Drlg. Co., Inc			
Fair Bldg., Fort Worth, Texas	Rotary, diesel, barge	2475	18,000
	Rotary, diesel, barge	1920	12,000
Terrebonne Parish (Offshore)			
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	1800	15,000
	Rotary, diesel	1350	14,000
	Rotary, diesel	1150	11,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	1500	18,000
Vermilion Parish			
Clegg & Hunt			
715 Houston Club Bldg., Houston, Tex.	Rotary diesel	800	11,500
	Rotary, steam		15,000
	Rotary, steam		14,000
G-B Equipment Corp.			
Box 277, Lockport, La.	Rotary, gas	375	8500
Falcon Seaboard Drlg. Co.			
Stanolind Bldg., Tulsa, Okla.	Rotary, steam		20,000
	Rotary, steam		20,000
Hawkins-Wilkins Production Co.			
373 San Jacinto Bldg., Houston, Texas	Rotary, steam		15,000
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	1500	13,500
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, steam		15,000
Southern Six Drlg. Co., Inc.			
Box 369, Opelousas, La.	Rotary, steam		14,000
Webster Parish			
Butler-Johnson, Inc.			
Box 306, Shreveport, La.	Rotary, gas-butane	550	8000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, steam		15,000
	Rotary, steam		14,000
	Rotary, steam		15,000
	Rotary, steam		15,000
	Rotary, steam		10,000
MARYLAND			
Pendleton County			
Chisler and Son			
Rt. 2, Fairview, West, Va.	Cable tool, gaso	110	1800
Prince Georges County			
Eakle & Holder Drlg. Co.			
116 Mulberry, Evansville, Ind.	Rotary, diesel	300	5500
MICHIGAN			
Arenac County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Rotary, gas-gaso	375	4000
Bay County			
Muskegon Development Co.			
432 Lyman Bldg., Muskegon, Mich.	Cable tool, butane	145	6000
	Cable tool, diesel	50	3500
	Cable tool, diesel	45	3500

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Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Clare County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Rotary, gas-gaso	575	7500
Isabella County			
Muskegon Development Co.			
432 Lyman Bldg., Muskegon, Mich.	Cable tool, gaso	145	5500
Lenawee County			
General Geophysical Co.			
750 Houston Club Bldg., Houston, Tex.	Rotary, butane	152	1000
Midland County			
Muskegon Development Co.			
432 Lyman Bldg., Muskegon, Mich.	Cable tool, diesel	50	5500
Newaygo County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Cable tool, gas-gaso	145	3500
Oceana County			
Fen-Par Exploration Co.			
Box 282, Grand Haven, Mich.	Rotary, diesel	80	2400
Ogemaw County			
Muskegon Development Co.			
432 Lyman Bldg., Muskegon, Mich.	Cable tool, diesel	50	5500
Scott Drlg., Inc.			
408 East 4th St., Clare, Mich.	Rotary, diesel	600	8500
Osceola County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Rotary, diesel	500	6000
Saginaw County			
Muskegon Development Co.			
432 Lyman Bldg., Muskegon, Mich.	Cable tool, diesel	50	5500
Tuscola County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Rotary, gas-gaso	660	10,000
MISSISSIPPI			
Adams County			
Dorris Ballew, Inc.			
Box 561, Natchez, Miss.	Rotary, diesel	1200	15,000
Petersen, Drlg. Co.			
306 Fairfield Bldg., Shreveport, La.	Rotary, diesel	500	9000
Forrest County			
Crawford Drlg. Co.			
Box 622, Shreveport, La.	Rotary, diesel	500	9000
Petersen Drilling Co.			
306 Fairfield Bldg., Shreveport, La.	Rotary, diesel	475	8500
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, diesel	520	10,000
Franklin County			
H. L. Rowley, Inc.			
Box 1784, Shreveport, La.	Rotary, diesel	1050	15,000
Greene County			
H. L. Rowley, Inc.			
Box 1784, Shreveport, La.	Rotary, diesel	1050	15,000
Jasper County			
Drilling & Exploartion Co. of Delaware, Inc.			
227 Johnson Bldg., Shreveport, La.	Rotary, gas-gaso	1050	15,000
	Rotary, gas-gaso	1050	15,000
	Rotary, gas-gaso	750	1000
	Rotary, gas-gaso	900	13,000
	Rotary, gas-gaso	900	13,000
Jefferson County			
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, diesel	450	8000
Jones County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1260	15,000
Crawford Drlg. Co.			
Box 622, Shreveport, La.	Rotary, steam	.....	15,000
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, diesel	400	6000
Madison County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	560	8000
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas-diesel	1500	14,000
Marion County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	560	8000
Pearl River County			
Crawford Drlg. Co.			
Box 622, Shreveport, La.	Rotary, steam	.....	10,000
Wilkinson County			
Sunnyland Contracting Co., Inc.			
Box 388, Rayne, La.	Rotary, diesel	450	8000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
MONTANA			
Billings County			
Reliable Drlg. Co., Inc.			
3086 Garden Ave., Billings, Mont.	Rotary, gas	350	5000
Carbon County			
Signal Drilling Co.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, diesel	800	9500
Carter County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, diesel	700	9000
Dawson County			
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, diesel	1000	10,000
Fallon County			
Clark Drlg. Co.			
Box 1743, Billings, Mont.	Rotary, diesel, gas-gaso	1050	10,500
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	10,000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg., Oklahoma City, Okla.	Rotary, gas-gaso	832	11,000
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas-diesel	1455	12,000
	Rotary, gas-diesel	1455	12,000
Glacier County			
M. H. O. Drlg. Co.			
Box 297, Cut Bank, Mont.	Cable tool, diesel	140	3000
	Cable tool, diesel	140	3000
Liberty County			
B & B Drlg. Co.			
Whitlash, Montana	Cable tool, gas-gaso	145	3500
Musselshell County			
Clark Drlg. Co.			
Box 1743, Billings, Mont.	Rotary, diesel, gas-gaso	525	6500
Pondera County			
J. W. Lawrence			
Box 942, Conrad, Mont.	Cable tool, gas-gaso	175	5000
	Cable tool, gas-gaso	125	3000
Treasure State Drlg. Co.			
Box 1712, Great Falls, Mont.	Cable tool, gas-gaso	140	3000
Powder River County			
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel	260	6000
Roosevelt County			
Zach Brooks Drlg. Co.			
Box 31, El Dorado, Ark.	Rotary, gas-diesel	1455	10,000
	Rotary, gas-diesel	1182	7000
Toole County			
M. H. O. Drlg. Co.			
Box 297, Cut Bank, Mont.	Cable tool, gas-gaso	180	3500
	Cable tool, diesel	225	5000
Washtenaw County			
Gordon Drlg. Co.			
Mt. Pleasant, Mich.	Rotary, gas-gaso	500	6000
Scott Drlg., Inc.			
408 E. 4th St., Clare, Mich.	Rotary, diesel	600	8500
	Rotary, diesel	300	4500
Wibaux County			
McAlester Fuel Co.			
Box 210, Magnolia, Ark.	Rotary, butane-gas	1050	14,000
J. D. Sprecher Drlg. Contractor			
Casper, Wyo.	Rotary, diesel	975	12,000
Yellowstone County			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, diesel	800	9000
NEBRASKA			
Banner County			
Garvey Drlg. Co.			
311 East 3rd St., Wichita, Kan.	Rotary	640	7500
	Rotary	558	8500
Miracle-Fifer Drlg. Co.			
1636 Welton St., Denver, Colo.	Rotary, butane	660	8500
Bushnell County			
L. C. Smitherman Drlg. Co.			
Box 627, Augusta, Kan.	Cable tool, butane	145	7500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Cheyenne County			
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, diesel	280	5500
Kimball County			
Garvey Drlg. Co.			
311 East 3rd St., Wichita, Kan.	Rotary	320	7500
Geo. G. Johnson Drlg. Co.			
1104 Mile High Center, Denver, Colo.	Rotary, gas	700	8000
Lohmann-Johnson Drlg. Co., Inc.			
320 Indiana Bldg., Evansville, Ind.	Rotary, diesel	480	5500
New Drlg. Co., Inc.			
1018 Patterson Bldg., Denver, Colo.	Rotary, gas-gaso	700	8000
	Rotary, gas-gaso	350	7500
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	450	7500
Signal Exploration Inc.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, gas-gaso	550	8500
Logan County			
New Drlg. Co., Inc.			
1018 Patterson Bldg., Denver, Colo.	Rotary, gas-gaso	500	6500
	Rotary, gas-gaso	250	6000
Sioux County			
Lohmann-Johnson Drlg. Co., Inc.			
320 Indiana Bldg., Evansville, Ind.	Rotary, gas	750	10,000
NEVADA			
Nye County			
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, diesel	600	9000
NEW MEXICO			
Bernalillo County			
Taylor Exploration Co., Inc.			
2118 Welch Ave., Houston, Texas	Rotary, gaso	75	1000
Chaves County			
Kerr-McGee Oil Industries Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	300	5000
Eddy County			
Ainsworth Inc.			
1002 Union Natl. Bk. Bldg.,			
Wichita, Kan.	Rotary, gaso	100	3000
Great Western Drlg. Co.			
509 North Loraine, Midland, Texas	Rotary, gas-gaso	1755	16,000
Kersey & Co.			
210 Booker Bldg., Artesis, N. M.	Cable tool, gas-gaso	185	5000
	Cable tool, gas-gaso	120	4000
	Cable tool, gas-gaso	120	3000
McDaniel & Beecherl Drlg. Co.			
607 Davis Bldg., Dallas, Texas	Rotary, gas-gaso	425	5000
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, diesel	290	3500
	Rotary, gas-gaso	125	2500
Guadlupe County			
D-K Drlg. Co.			
504 Leggett Bldg., Midland, Texas	Rotary, gas-gaso	675	7500
LaMance Drlg. Co., Ltd.			
Box 667, Hereford, Texas	Rotary, gas-gaso	600	7500
Lea County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	840	10,000
Blount Drlg.			
114 Central Bldg., Midland, Texas	Rotary, diesel	275	5500
Brantly Drlg. Co., Inc.			
107 Capitol Bldg., Midland, Texas	Rotary, gas	800	14,000
	Rotary, gas	750	11,000
Coroco Drlg. Co.			
2807 Mercantile Bk. Bldg., Dallas, Tex.	Rotary, gas-gaso	900	15,000
	Rotary, diesel	500	15,000
Davidson Drlg. Co., Inc.			
1004 Cont. Life Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	750	10,000
Delaware Drillers Inc.			
204 Chadbourne Bldg.,			
San Angelo, Texas	Rotary, butane-gas	560	6500
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	900	15,000
D-K Drilling Co.			
504 Leggett Bldg., Midland, Texas	Rotary, gas-gaso	675	8500
Donnell Drlg. Co.			
607 Texas Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	975	12,000
	Rotary, gas-gaso	650	6000
Fleeger-Riley Drlg. Co., Inc.			
271 Meadows Bldg., Dallas, Texas	Rotary, diesel	350	5000
Frawley Drlg. Co.			
823 S. Detroit, Tulsa, Okla.	Rotary, gas-gaso	1100	13,000
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	1260	15,000
	Rotary, gas-gaso	750	7500
Gypsy Exploration Co., Inc.			
204 Chadbourne Bldg.,			
San Angelo, Texas	Rotary, diesel	600	6000
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1500	13,000
LaMance Drlg. Co., Ltd.			
Box 667, Hereford, Texas	Rotary, gas-gaso	500	6500
Lowe Drlg. Co.			
Box 832, Midland, Texas	Rotary, gas-gaso	1350	14,000
Makin Drlg. Co.			
Box 1628, Hobbs, N. M.	Rotary, gas-gaso	975	13,000
	Rotary, gas-gaso	750	8000
	Rotary, gas-gaso	750	8000
	Rotary, gas-gaso	750	6700
	Rotary, gas-gaso	450	5000
McAlester Fuel Co.			
Box 210, Magnolia, Ark.	Rotary, butane-gas	1050	14,000
Rowan Drlg. Co., Inc.			
Fair Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1110	11,000
A. W. Thompson Inc.			
Box 992, Odessa, Texas	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	600	7500
McKinley County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	800	7500
	Rotary, diesel	600	5500
Rio Arriba County			
Arapahoe Drlg. Co.			
504 Colorado Bldg., Denver, Colo.	Rotary, gas-gaso	350	6500
Fleeger-Riley Drlg. Co., Inc.			
271 Meadows Bldg., Dallas, Texas	Rotary, diesel	600	8500
San Juan County			
Empire States Drlg. Co.			
Box 891, Farmington, N. M.	Rotary, diesel	500	6500
	Rotary, gas-gaso	250	5000
Fleeger-Riley Drlg. Co., Inc.			
271 Meadows Bldg., Dallas, Texas	Rotary, diesel	600	8500
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	675	7500
	Rotary, gas-gaso	798	7500
	Rotary, gas-gaso	675	7500
	Rotary, gas-gaso	840	7500
	Rotary, gas-gaso	750	7500
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.,			
Tulsa, Okla.	Rotary, gas-gaso	650	8500
H. B. Lynn			
Box 446, Farmington, N. M.	Rotary, gas-gaso	700	8500
	Rotary, gas-gaso	700	8500
R & G Drlg. Co., Inc.			
Box 1848, Farmington, N. M.	Rotary, butane	165	3000
Totah Drlg. Co.			
820 Simms Bldg., Albuquerque, N. M.	Rotary, gas-gaso	150	3000
	Rotary, gas-gaso	150	3000
NORTH DAKOTA			
Bottineau County			
Calvert Drlg. Inc.			
Olney, Ill.	Rotary, gas-gaso	290	6500
Cardinal Drlg. Co.			
410 Thayer, Bismarck, N. D.	Rotary, diesel	250	5500
	Rotary, diesel	200	5000
	Rotary, diesel	140	4000
Burke County			
Calvert Drlg. Inc.			
Olney, Ill.	Rotary, diesel	520	9000
Dunn County			
Penrod Drlg. Co.			
418 Market St., Shreveport, La.	Rotary, diesel	1200	10,000
	Rotary, diesel	730	9000
McKenzie County			
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	10,000
Rowan Drlg. Co., Inc.			
Fair Bldg., Fort Worth, Texas	Rotary, gas-gaso	1680	11,000
	Rotary, gas-gaso	1120	11,000
Paul F. Rutledge			
Box 2239, Santa Fe, N. M.	Rotary, gas-gaso	750	12,500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Renville County			
Paul F. Rutledge			
Box 2239, Santa Fe, N. M.	Rotary, gas-gaso	750	10,000
Williams County			
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	800	7500
Penrod Drlg. Co.			
418 Market St., Shreveport, La.	Rotary, gas or butane	820	9000
Rowan Drlg. Co., Inc.			
Fair Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1503	11,000
Paul F. Rutledge			
Box 2239, Santa Fe, N. M.	Rotary, gas-gaso	750	12,500
OHIO			
Coles County			
Don Slape Drlg. Co.			
Box 432, Olney, Ill.	Rotary, diesel	460	5500
Wood County			
H. J. Lininger			
207 S. 4th, Upper Sandusky, Ohio	Cable tool, diesel	175	3500
Wyandot County			
H. J. Lininger			
207 S. 4th, Upper Sandusky, Ohio	Cable tool, gas-gaso	65	1800
	Cable tool, gas-gaso	78	2500
OKLAHOMA			
Alfalfa County			
Newton Barrett Drlg. Co.			
423 Masonic Bldg., Shawnee, Okla.	Rotary, gas-gaso	750	8500
Beaver County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	560	8000
	Rotary, gas-gaso	510	7000
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	685	8500
Big X Drlg. Co., Inc.			
2905 First Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	750	9000
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	700	7500
Kerr-McGee Oil Industries Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	556	8000
Midwestern Drillers Inc.			
Wright Bldg., Tulsa, Okla.	Rotary, diesel	650	8500
	Rotary, gas-gaso	560	8500
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	450	7500
Caddo County			
Reading and Bates Inc.			
1502 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1600	16,000
Carter County			
Clabaugh Drlg. Co.			
810 Braniff Bldg.,			
Oklahoma City, Okla.	Cable tool, gas-gaso	145	8500
	Cable tool, gas-gaso	145	5000
Fain-Porter Drlg. Co.			
2410 First Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	300	5000
Gibson & Holliman			
1021 Fidelity Union Life Bldg.,			
Dallas, Texas	Rotary, gas-gaso	500	7500
	Rotary, gas-gaso	550	7500
	Rotary, gas-butane	370	7500
Preston Carter Drlg. Co.			
Box 396, Gilbert Bldg.,			
Ardmore, Okla.	Rotary, gas-gaso	700	11,000
	Rotary, gas-gaso	450	7500
	Rotary, gas-gaso	225	5000
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	500	7500
Schafer Drlg. Co.			
2400 Liberty Bank Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	302	6000
	Rotary, gas-gaso	302	7500
Webster Drlg. Co.			
424 So. Cheyenne, Tulsa, Okla.	Rotary, gas-gaso	450	7500
Cleveland County			
An-Son Drlg. Co.			
3814 N. Sante Fe,			
Oklahoma City, Okla.	Rotary, gas-gaso	650	9500
Bryant-Hayward Drlg. Co.			
Box 4627, Oklahoma City, Okla.	Rotary, gas-gaso	650	9250
	Rotary, gas-gaso	600	8500
	Rotary, gas-gaso	600	8500
Calvert Drlg. Inc.			
Olney, Ill.	Rotary, gas-gaso	570	9000
Fain-Porter Drlg. Co.			
2410 First Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	750	11,000
	Rotary, gas-gaso	500	8000
Meridian Drlg. Co., Inc.			
921 City Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, gas, butane	450	8500
Nuckolls-Bell Drlg. Co.			
2414 1st Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	704	9000
Comanche County			
J H & S Petroleum Corp			
916½ Main St., Duncan, Okla.	Cable tool, gas-gaso	175	3000
Creek County			
Ainsworth Inc.			
1002 Union Natl. Bk. Bldg.,			
Wichita, Kan.	Rotary, gaso	100	3000
Glenn Gillespie & Sons			
Box 907, Cushing, Okla.	Rotary, diesel	260	5500
	Rotary, diesel	260	5500
Republic Drlg. Co.			
Box 7035, Tulsa, Okla.	Cable tool, gas-gaso	140	3000
Unit Drlg. Co.			
200 North Main, Bristow, Okla.	Rotary, gas-gaso	240	5500
Wade Drlg. Co.			
Box 822, Drumwright, Okla.	Rotary, diesel	185	3000
Garfield County			
Admiral Drlg. Co.			
Perry, Okla.	Cable tool, gas	160	8000
Garvey County			
Don Johnston Drlg. Co.			
623 Empire Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	650	7500
Garvin County			
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	1250	16,000
	Rotary, gas-gaso	1350	16,000
Big X Drlg. Co., Inc.			
2905 First Natl. Bldg.			
Oklahoma City, Okla.	Rotary, gas-gaso	750	10,000
Crown Drlg. Co.			
2619 First Natl. Bldg.			
Oklahoma City, Okla.	Rotary, gas-gaso	475	8000
T. T. Eason & Co.			
1211 Colcord Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	1100	12,000
Goldsmith & Perkins, Inc.			
Perkins Bldg., Duncan, Okla.	Rotary, gas-butane	800	12,000
	Rotary, gas-butane	675	8500
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	13,000
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, gas butane	825	10,500
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.,			
Tulsa, Okla.	Rotary, gas-gaso	1000	12,000
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	832	11,000
	Rotary, gas-gaso	832	11,000
Preston Carter Drlg. Co.			
Box 396, Gilbert Bldg.,			
Ardmore, Okla.	Rotary, gas-gaso	1050	16,000
	Rotary, gas-gaso	450	8000
Reading and Bates, Inc.			
1502 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1200	14,000
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	1010	12,000
Webster Drlg. Co.			
424 S. Cheyenne, Tulsa, Okla.	Rotary, gas-gaso	1050	12,000
	Rotary, gas-gaso	650	10,000
	Rotary, gas-gaso	650	8500
	Rotary, gas-gaso	600	7500
Chester H. Westfall Drlg. Co.			
1202 Hunt Bldg., Tulsa, Okla.	Rotary, gas-gaso	700	10,400

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Grady County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1260	15,000
	Rotary, gas-gaso	1260	15,000
	Rotary, gas-gaso	1260	15,000
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	1350	16,000
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	10,000
	Rotary, diesel	1300	13,000
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, gas-butane	300	5000
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	1125	14,000
Chester H. Westfall Drlg. Co.			
1202 Hunt Bldg., Tulsa, Okla.	Rotary, gas-gaso	700	10,400
	Rotary, gas-gaso	700	10,400
Grant County			
Calvert Drlg., Inc.			
Olney, Ill.	Rotary, diesel	520	9000
Greer County			
Bolin Oil Co.			
1120 Oil and Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	176	4000
Jackson County			
Zephyr Drlg. Corp.			
1111 First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	450	7500
Kay County			
L. C. Smitherman Drlg. Co.			
Box 627, Augusta, Kan.	Rotary, butane	145	4500
Kingfisher County			
Webster Drlg. Co.			
424 S. Cheyenne, Tulsa, Okla.	Rotary, gas-gaso	600	8000
Lincoln County			
Austin-Dunham			
Box 85, Seminole, Okla.	Rotary, gas-gaso	570	6500
Frizzell Drlg. Co.			
108 N.W. 2nd, Oklahoma City, Okla.	Rotary, gas-gaso	600	7500
Newton Barrett Drlg. Co.			
423 Masonic Bldg., Shawnee, Okla.	Rotary, gas-gaso	450	6800
Republic Drlg. Co.			
Box 7035, Tulsa, Okla.	Rotary, gas-gaso	220	4500
Seran & Howard Drlg. Co.			
Okemah Hotel, Okemah, Okla.	Rotary, gas	200	5000
Wade Drlg. Co.			
Box 822, Drumright, Okla.	Rotary, diesel	225	4500
Logan County			
Branyan Drlg. Co.			
Cushing, Okla.	Rotary, diesel	700	9000
Cyclom Drlg.			
Tulsa, Okla.	Rotary, diesel	300	5500
Newton Barrett Drlg. Co.			
423 Masonic Bldg., Shawnee, Okla.	Rotary, gas-gaso	450	6800
Nuckolls-Bell Drlg. Co.			
2414 First Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	352	7500
Sabre Drlg. Co.			
222 Hughes Bldg., Cushing, Okla.	Rotary, diesel	350	6500
Major County			
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Cable tool, diesel	150	6000
Marshall County			
Crown Drlg. Co.			
2619 First Natl. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	575	9000
T. T. Eason & Co.			
1211 Colcord Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	750	9500
Webster Drlg. Co.			
424 S. Cheyenne, Tulsa, Okla.	Rotary, gas-gaso	700	8500
McIntosh County			
Newton Barrett Drlg. Co.			
423 Masonic Bldg., Shawnee, Okla.	Rotary, diesel	300	5500
Noble County			
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	450	6500
Oklahoma County			
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	770	9500
Okmulgee County			
Acacia Drlg. Co.			
509 McFarlin Bldg., Tulsa, Okla.	Cable tool, diesel	175	4000
	Cable tool, diesel	175	4000
Osage County			
Cyclom Drlg.			
Tulsa, Okla.	Rotary, gas-gaso	225	4500
Glenn Gillespie & Sons			
Box 907, Cushing, Okla.	Rotary, diesel	225	4000
	Rotary, diesel	190	4000
	Rotary, diesel	190	4000
	Rotary, gas-gaso	145	3000
Mesker Drlg. Co.			
1129 E. 15th St., Tulsa, Okla.	Rotary, gas-gaso	200	3000
	Rotary, gas-gaso	100	2000
	Rotary, gas gaso	200	3000
Reed Drlg. Co., Inc.			
1408 First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	235	5000
Republic Drlg. Co.			
Box 7035, Tulsa, Okla.	Rotary, gas-gaso	165	3500
	Rotary, gas-gaso	165	3500
Reserve Drlg. Co., Inc.			
703 Union Natl. Bldg., Wichita, Kan.	Rotary, diesel	225	5000
Pawnee County			
Reed Drlg. Co., Inc.			
1408 First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	410	5500
Payne County			
Branyan Drlg. Co.			
Cushing, Okla.	Rotary, diesel	600	6000
Republic Drlg. Co.			
Box 7035, Tulsa, Okla.	Rotary, gas-gaso	220	5700
Sabre Drlg. Co.			
222 Hughes Bldg., Cushing, Okla.	Rotary, diesel	300	5000
Pottawatomie County			
Newton Barrett Drlg. Co.			
423 Masonic Bldg., Shawnee, Okla.	Rotary, diesel	350	5800
Roger Mills County			
Preston Carter Drlg. Co.			
Box 396, Ardmore, Okla.	Rotary, gas-gaso	450	8000
Seminole County			
Austin Drlg. Co.			
Box 85, Seminole, Okla.	Rotary, diesel, gas-gaso	265	5500
Wade Drlg. Co.			
Box 822, Drumright, Okla.	Rotary, diesel	100	1800
Stephens County			
An-Son Drlg. Co.			
3814 N. Santa Fe,			
Oklahoma City, Okla.	Rotary, gas-gaso	540	8000
Admiral Drlg. Co.			
Perry, Okla.	Cable tool, gas	160	8000
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	1150	13,000
Clabaugh Drlg. Co.			
810 Braniff Bldg.,			
Oklahoma City, Okla.	Cable tool, gas-gaso	145	8500
	Cable tool, gas-gaso	145	8500
	Cable tool, gas-gaso	145	8500
T. T. Eason & Co.			
1211 Colcord Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	400	6300
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	426	7500
Texas County			
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.,			
Tulsa, Okla.	Rotary, gas-gaso	675	9000
Tillman County			
Zephyr Drlg. Corp.			
1111 First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	450	7500
Washita County			
Reading & Bates, Inc.			
1502 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	1000	10,000
Woodward County			
Baker & Tayler Drlg. Co.			
712 1st Natl. Bk. Bldg., Amarillo, Tex.	Rotary, gas	1800	18,000
OREGON			
Malheur County			
Colorado Wyoming Drlg. Co.			
1119 Mile High Center, Denver, Colo.	Rotary, gas-propane	650	10,000
PENNSYLVANIA			
Berks County			
Eakle & Holder Drlg. Co.			
116 Mulberry, Evansville, Ind.	Rotary, diesel	260	4500

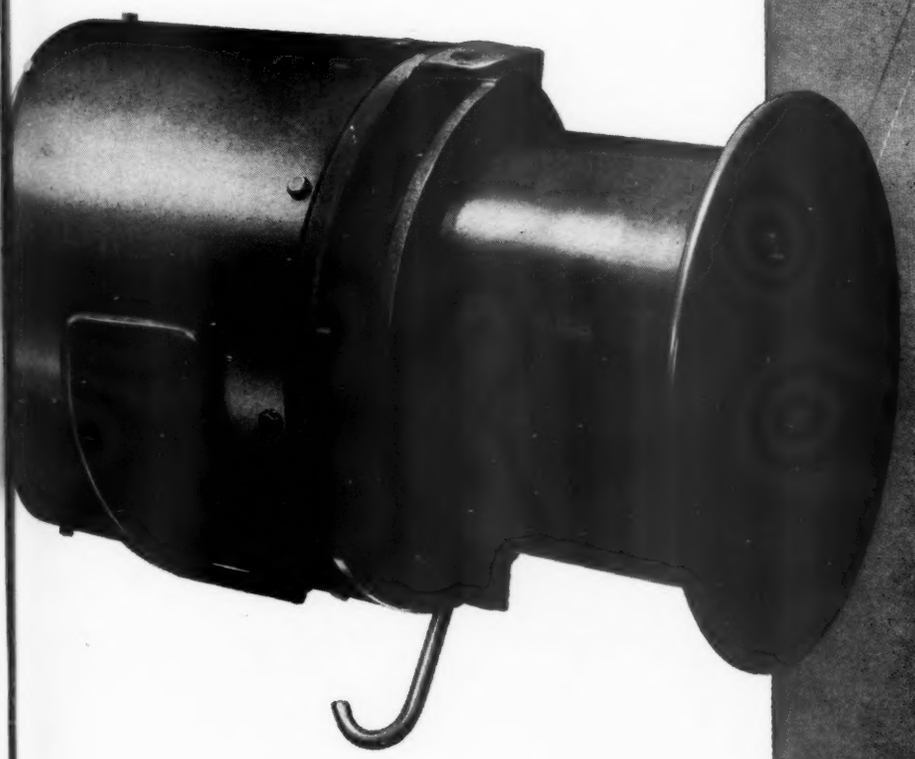
Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Warren County			
Grosch Bros.			
128 Russell, Warren, Pa.	Cable tool, gas-gaso	60	2500
	Cable tool, gas-gaso	60	2500
West Moreland County			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	800	9000
SOUTH DAKOTA			
Custer County			
Signal Drilling Co.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, diesel	200	4500
TEXAS			
Anderson County			
Maxwell Herring Drlg. Corp.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	750	9500
Andrews County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, diesel	1400	15,000
	Rotary, diesel	1400	15,000
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	1720	15,000
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, gas-gaso	900	11,000
	Rotary, gas-gaso	1250	15,000
The Denver Co.			
1904 Great Plains Life Bldg., Lubbock, Texas	Rotary, gas-gaso	300	5700
Donnell Drlg. Co.			
607 Texas Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	1300	15,000
D-K Drlg. Co.			
504 Leggett Bldg., Midland, Texas	Rotary, gas-gaso	675	7500
Empire Drlg. Co.			
1507 Mercantile Bk. Bldg., Dallas, Tex.	Rotary, gas-gaso	1000	12,500
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	1125	15,000
	Rotary, diesel	1200	10,000
	Rotary, gas-gaso	1200	15,000
	Rotary, gas-gaso	1260	15,000
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	1000	13,500
	Rotary, gas-gaso	1000	13,500
	Rotary, gas-gaso	1000	13,500
	Rotary, gas-gaso	900	11,000
	Rotary, gas-gaso	1000	12,500
LaMance Drlg. Co., Ltd.			
Box 667, Hereford, Texas	Rotary, gas-gaso	600	7500
Lowe Drlg. Co.			
Box 832, Midland, Texas	Rotary, gas-gaso	1250	12,500
	Rotary, gas-gaso	950	12,500
	Rotary, gas-gaso	200	8500
	Rotary, gas-gaso	1250	14,000
	Rotary, gas-gaso	950	12,500
	Rotary, gas-gaso	1250	14,000
McQueen & Stout Drlg. Co.			
1010 1st Natl. Bk. Bldg., Odessa, Tex.	Rotary, gas-gaso	165	5500
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas-butane	1800	15,000
	Rotary, gas-butane	1425	14,000
	Rotary, diesel	730	9000
Rowan Drlg. Co., Inc.			
Fair Bldg., Fort Worth, Texas	Rotary, gas-gaso	1480	15,000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	1200	12,000
A. W. Thompson, Inc.			
Box 992, Odessa, Texas	Rotary, gas-gaso	750	10,000
	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	750	10,000
Tex-Mex Drlg. Co.			
1211 Fidelity Union Life Bldg., Dallas, Texas	Rotary, gas-gaso	450	6000
	Rotary, gas-gaso	450	6000
Urice Drlg. Co.			
615 Fort Worth Club Bldg., Fort Worth, Texas	Rotary, gas-gaso	500	7500
Western Drlg Co., Inc.			
902 Lubbock Natl. Bk. Bldg., Lubbock, Texas	Cable tool, gas-gaso	165	4000
	Rotary, gas-gaso	1300	13,000
	Rotary, diesel	750	9500
	Rotary, diesel	655	6500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Aransas County			
Conroe Drlg. Co.			
307 Wilson Tower, Corpus Christi, Texas	Rotary, steam		14,000
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower, Corpus Christi, Texas	Rotary, diesel, mobile platform	2250	18,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	730	9000
Archer County			
Gray Drlg. Co.			
220 Wichita Natl. Bk. Bldg., Wichita Falls, Texas	Rotary, gas-gaso	400	5000
R-G Drlg. Co.			
403 City Natl. Bk. Bldg. Wichita Falls, Texas	Rotary, gas-gaso	650	6500
Atascosa County			
Beard Drlg., Inc.			
814 South Texas Bldg., San Antonio, Texas	Rotary, butane-gas	250	6000
Buzzini Drlg. Co.			
541 Milam Bldg., San Antonio, Texas	Rotary, gas-butane	712	10,000
Kirby-Southworth Drlg. Co.			
549 San Jacinto Bldg., Houston, Texas	Rotary, gas-gaso	280	6500
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, gas-gaso	700	9000
Martin & Holmes Oil Well Ser. Co.			
4730 Ayers, Corpus Christi, Texas	Rotary, gas-gaso	370	6500
Bandera County			
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	900	11,000
Bee County			
Field Drlg. Co.			
1409 Milam Bldg., San Antonio, Texas	Rotary, diesel	260	6000
Miller Bros. & Bowler			
Box 611, Alice, Texas	Rotary, gas-butane	525	8500
Rhodes & Hicks Drlg. Corp.			
Box 1395, Alice, Texas	Rotary, gas-gaso	200	5500
Bexar County			
Taylor Exploartion Co., Inc.			
2118 Welch Ave., Houston, Texas	Rotary, butane	125	3000
Walters Drlg. Co., Inc.			
4114 McMillan, Dallas, Texas	Rotary, gas		600
Brazoria County			
Blanton Drlg. Co.			
2030 Gulf Bldg., Houston, Texas	Rotary, steam		12,000
Carnes W. Weaver Drlg. Co.			
326 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	650	6000
The Grey Wolf Drlg. Co.			
1405 South Coast Life Bldg., Houston, Texas	Rotary, steam		12,500
	Rotary, gas-gaso	660	9500
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas	600	10,000
	Rotary, diesel	385	6000
Prince Drlg. Co.			
1605 Bk. of Commerce Bldg., Houston, Texas	Rotary, steam	1200	13,500
Morris & Hamilton, Inc.			
1521 Commerce Bldg., Houston, Tex.	Rotary, gas-gaso	1125	8500
C. W. Strotman Drlg. Co.			
620 S. 30th St., Mattoon, Ill.	Cable tool, gas-gaso		3500
	Cable tool, gas-gaso		3500
	Cable tool, gas-gaso		3500
	Rotary, gas-gaso	750	10,000
Brooks County			
Field Drlg. Co.			
1409 Milam Bldg., San Antonio, Tex.	Rotary, diesel	752	10,000
Flournoy Drlg. Co.			
Box 1578, Alice, Texas	Rotary, gas-gaso	185	6000
Holmes Drlg. Co.			
1045 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	1000	11,000
Brown County			
Kent & Preston			
425 Sayles Blvd., Abilene, Texas	Cable, diesel	160	6000
Caldwell County			
Miller Bros. & Bowling			
Box 611, Alice, Texas	Rotary, gas-butane	450	7000

American Iron

UNIVERSAL FRICTION CATHEADS

with NEW DETACHABLE SPOOL!



NOW, A BIG PLUS VALUE is added to the many features of the American Iron Universal Friction Makeup and Breakout Catheads, so extensively used throughout the oil country. The new, detachable, steel spool offers many advantages, a few of which are listed below.

● Spool is easily removed, increasing road clearance . . . reducing drawworks transportation problems ● Steel spool, yet retaining cast iron alloy friction flange for efficient friction qualities ● Longer and larger diameter spool ● Friction part of cathead may be operated without spool with no down time ● Steel spool fits both makeup or breakout cathead ● Two piece spool design eliminates warping of friction clutch face ➲ Request Bulletin 655 for additional information.

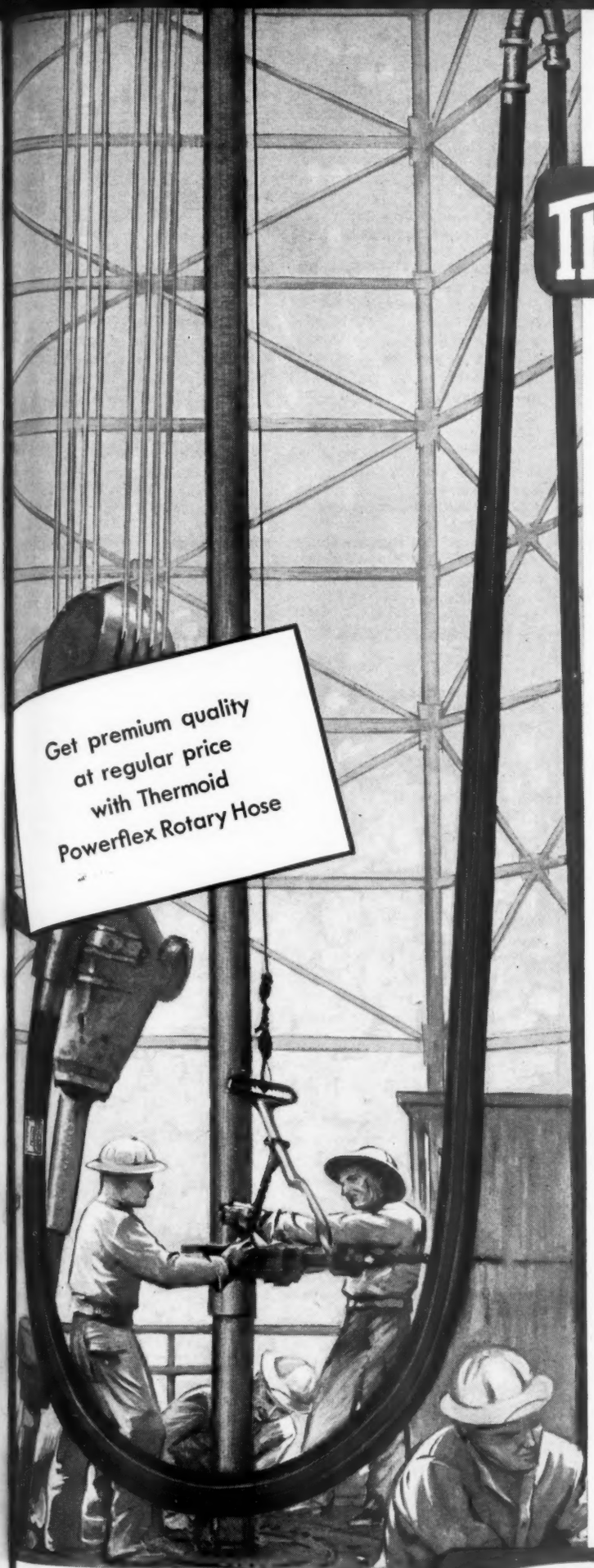
AMERICAN IRON & MACHINE WORKS COMPANY, INC. Oklahoma City

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY, New York

AMERICAN IRON & MACHINE WORKS CO. · MANUFACTURERS OF OIL FIELD EQUIPMENT · A · REG. U.S. PAT. OFF. · OKLAHOMA CITY U.S.A. ·

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Travis Drillers, Inc.			
202 W. 1st St., Austin, Texas	Rotary, gas-gaso	260	5000
Calhoun County			
Blanton Drlg. Co.			
2030 Gulf Bldg., Houston, Texas	Rotary, steam	.....	10,500
Conroe Drlg. Co.			
307 Wilson Tower,			
Corpus Christi, Texas	Rotary, steam	1400	12,000
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary-barge, diesel	1275	15,000
	Rotary-barge, diesel	785	11,000
Layton Brown Drlg. Co.			
Box 4, Woodsboro, Texas	Rotary, steam	1050	10,000
	Rotary, diesel	800	10,000
Rock Hill Drlg. Co.			
704 Milam Bldg., San Antonio, Tex.	Rotary, gas-gaso	600	9000
Callahan County			
Herb Exploration Co.			
342 Lexington Ave., Abilene, Texas	Rotary, gas-gaso	.....	1750
Lamar H. Moore Drlg. Co.			
Box 29, Abilene, Texas	Rotary, gas-gaso	185	5500
Low Drlg. Co.			
Box 1112, Cisco, Texas	Rotary, butane	290	7000
Cameron County			
Holmes Drlg. Co.			
1045 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	1000	11,000
Carson County			
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.,			
Tulsa, Okla.	Rotary, gas-gaso	450	5000
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	213	5000
Cass County			
Butler-Johnson, Inc.			
Box 306, Shreveport, La.	Rotary, gas-butane	450	7000
Mustang Drlg. Corp.			
1201 Peoples Bk. Bldg., Tyler, Texas	Rotary, diesel	360	6500
C. M. Robenson Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas-gaso	300	7200
South States Drlg. Co.			
Box 147, Longview, Texas	Rotary, diesel	350	8000
	Rotary, diesel	350	8000
Chambers County			
Carnes W. Weaver Drlg. Co.			
326 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	500	7500
Clegg & Hunt			
715 Houston Club Bldg., Houston, Tex.	Rotary, diesel	880	10,500
Morris & Hamilton, Inc.			
1521 Commerce Bldg., Houston, Texas	Rotary, diesel	1500	16,000
Cherokee County			
Robert M. Bass			
Box 471, Kilgore, Texas	Rotary, gas-gaso	200	5000
Gibson Drlg. Co.			
Box 214, Kilgore, Texas	Rotary, gas-gaso	250	6000
Maxwell Herring Drlg. Corp.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	250	5500
Clay County			
W. B. Omohundro			
102 Oil Center, Wichita Falls, Texas	Rotary, butane	650	8000
Cochran County			
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, diesel	515	5000
	Rotary, diesel	580	6000
Coke County			
CB Drlg. Co.			
Oklahoma City, Okla.	Rotary, gas-gaso	650	9000
Delaware Drillers, Inc.			
204 Chadbourne Bldg.,			
San Angelo, Texas	Rotary, diesel-butane	126	4500
Dual Drlg. Co.			
1111 City Natl. Bk. Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	700	9000
	Rotary, gas-gaso	700	10,000
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, diesel	750	9500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Coleman County			
Hack Drlg. Co.			
Box 1636, Abilene, Texas	Rotary, butane	412	8500
A. B. See Drlg. Co., Inc.			
206 Petroleum Bldg., Abilene, Texas	Rotary, gas-gaso	200	5000
Brannon & Murray Drlg. Co.			
Coleman Natl. Bk. Bldg.,			
Coleman, Texas	Rotary, gas-gaso	220	5000
Colorado County			
Mangum Drlg. Co.			
834 Esperson Bldg., Houston, Texas	Rotary, steam	.....	16,000
Meredith & Co.			
1027 Pioneer American Bldg.,			
Houston, Texas	Rotary, gas-gaso	975	13,000
Prince Drlg. Co.			
1605 Bk. of Commerce Bldg.,			
Houston, Texas	Rotary, gas-butane	700	10,500
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	1149	11,000
Commanche County			
Kent & Preston			
425 Sayles Blvd., Abilene, Texas	Cable, gas-butane	120	4500
Cooke County			
G & T Drlg. Co.			
Box 67, Muenster, Texas	Rotary, diesel	185	3000
Cottle County			
Edgar Davis Drlg. Co.			
617 F & M Bk. Bldg., Abilene, Texas	Rotary, gas-gaso	450	8000
Crane County			
Brantly Drlg. Co., Inc.			
109 Capitol Bldg., Midland Texas	Rotary, gas	250	4000
Davidson Drlg. Co., Inc.			
1004 Continental Life Bldg.,			
Fort Worth, Texas	Rotary, diesel	750	10,000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	700	7000
McDaniel & Beecherl Drlg. Co.			
607 Davis Bldg., Dallas, Texas	Rotary, gas-gaso	550	10,000
McQueen & Stout Drlg. Co.			
1010 First Natl. Bk. Bldg., Dallas, Tex.	Rotary, gas-gaso	165	5500
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	766	7000
Urice Drlg. Co.			
615 Ft. Worth Club Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	290	5500
	Rotary, gas-gaso	140	3000
Crockett County			
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, gas-gaso	750	9500
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	1050	15,000
McQueen & Stout Drlg. Co.			
1010 1st Natl. Bk. Bldg., Odessa, Tex.	Rotary, gas-gaso	165	5500
Triangle Drlg. Co.			
McCamey, Texas	Cable tool, butane	180	5000
	Cable tool, butane	120	3500
Dawson County			
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	818	11,000
Makin Drlg. Co.			
Box 1628, Hobbs, N. M.	Rotary, gas-gaso	975	12,000
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Cable tool, gas-gaso	185	5000
	Cable tool, gas-gaso	185	5000
Dewitt County			
Buzzini Drlg. Co.			
541 Milam Bldg., San Antonio, Texas	Rotary, gas butane	930	12,000
Dickens County			
Brannon & Murray Drlg. Co.			
Coleman Natl. Bk. Bldg.,			
Coleman, Texas	Rotary, gas-gaso	530	7000
Dimmit County			
Sutton Drlg. Co.			
4600 Broadway, San Antonio, Texas	Rotary, diesel	350	6500
	Rotary, diesel	400	6500
Duval County			
Field Drlg. Co.			
1409 Milam Bldg., San Antonio, Tex.	Rotary, diesel	520	8500



Thermoid

POWERFLEX Rotary Hose

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None have been able to fully match the strength and flexibility of Thermoid Powerflex Rotary Hose.

Powerflex is made of oil-and-abrasion-resistant synthetic rubber, reinforced with impregnated multi-ply woven fabric and high tensile steel cable. Its tough, extra-heavy cover resists weather and abrasion. The materials used in Powerflex are available to any hose manufacturer. But it's the way Thermoid wraps and couples Powerflex Hose that prevents duplication.

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Thermoid

Powerflex Rotary Hose • Trioflex Slim-Hole Rotary Hose • Mud-Flo Slush Pump Hose • Flexible Discharge Units • F.H.P. and Multiple V-Belts • Oil Country Flat Belting

Wire Line Turn Backs • No-Wip Line Savers • Stuffing Box Rings • All Types of Hose • Molded Specialties • Brake Blocks

Thermoid Company • Offices & Factories: Trenton, N. J., Nephi, Utah

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Flournoy Drlg. Co.			
Box 1578, Alice, Texas	Rotary, gas-gaso	320	6500
Miller Bros. & Bowling			
Box 611, Alice, Texas	Rotary, gas-butane	350	5500
Eastland County			
Edwards Drlg. Co.			
Box 1140, Graham, Texas	Rotary, gas-gaso	500	7500
Oney Drlg. Co.			
Box 425, Graham, Texas	Cable tool, gas-gaso	200	4500
Ector County			
Capitan Drlg. Co., Inc.			
Box 671, Odessa, Texas	Rotary, gas-gaso	450	8000
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, gas-gaso	1250	15,000
Drilling & Exploration Co. of Delaware, Inc.			
Union Oil Bldg., Midland Texas	Rotary, gas-gaso	1000	17,000
Eastland Oil Co.			
Continental Life Bldg., Ft. Worth, Tex.	Cable tool, gas-gaso	120	4500
	Rotary, gas-gaso	540	7500
	Rotary, gas-gaso	750	10,000
	Rotary, gas-gaso	450	7000
	Rotary, gas-gaso	600	10,000
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	1260	15,000
Highland Drlg. Co.			
Box 671, Odessa, Texas	Rotary, gas-gaso	450	8000
	Rotary, diesel	300	6000
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.			
Tulsa, Okla.	Rotary, gas-gaso	650	8500
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	1000	13,500
Lowe Drlg. Co.			
Box 832, Midland, Texas	Rotary, gas-gaso	950	12,500
McQueen & Stout Drlg. Co.			
1010 1st Natl. Bk. Bldg., Odessa, Tex.	Rotary, gas-gaso	165	5500
	Cable tool, gas-gaso	165	5500
	Cable tool, gas-gaso	145	4500
	Cable tool, diesel	150	4500
	Cable tool, diesel	165	4500
	Rotary, gas-gaso	165	5500
Makin Drlg. Co.			
Box 1628, Hobbs, N. M.	Rotary, gas-gaso	975	13,000
	Rotary, gas-gaso	750	8000
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	1480	14,000
	Rotary, gas-gaso	1680	14,000
	Rotary, gas-gaso	1680	14,000
	Rotary, gas-gaso	1480	14,000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	1350	15,000
A. W. Thompson, Inc.			
Box 992, Odessa, Texas	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	1650	16,000
	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	1050	13,500
	Rotary, gas-gaso	750	10,000
Warton Drlg. Co.			
Box 2807, Odessa, Texas	Rotary, diesel	600	800
Art West Drlg. Co.			
Box 1545, Odessa, Texas	Cable tool, gas	185	9000
Fayette County			
Hamman Oil & Refining Co.			
Box 13028, Houston, Texas	Rotary, butane	120	3000
Sutton Drlg. Co.			
4600 Broadway, San Antonio, Tex.	Rotary, gas-gaso	125	2500
	Rotary, diesel	225	4000
Fisher County			
Foree-Thomas Drlg. Co.			
602 1st Nat. Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	500	5000
Frawley Drlg. Co.			
823 S. Detroit, Tulsa, Okla.	Rotary, gas-gaso	850	10,000
General Geophysical Co.			
750 Houston Club Bldg.,			
Houston, Texas	Rotary, butane	500	7500
Lamar H. Moore Drlg. Co.			
Box 29, Abilene, Texas	Rotary, gas-gaso	552	7500
Moore & Moore Drlg. Co.			
Box 29, Abilene, Texas	Rotary, gas-gaso	185	5500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	600	9000
R-H-K Drlg. Co., Ltd.			
111 Wagstaff Bldg., Abilene, Texas	Rotary, gas-gaso	555	7500
	Rotary, gas-gaso	555	7500
Rheay & Reynolds Drlg. Co.			
404 Petroleum Bldg., Abilene, Texas	Rotary, gas-gaso	370	5000
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	834	7500
Urice Drlg. Co.			
615 Ft. Worth Club Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	700	8500
West Central Drlg. Co.			
617 F & M Bk. Bldg., Abilene, Texas	Rotary, gas-gaso	225	5000
	Rotary, gas-gaso	700	12,000
Ford County			
Ace Drlg. Co.			
1800 Republic Natl. Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	750	8000
Fort Bend County			
Blanton Drlg. Co.			
2030 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	678	8000
Mangum Drlg. Co.			
834 Esperson Bldg., Houston, Texas	Rotary, gas-gaso	700	9200
Steen Drlg. Co.			
604 West Bldg., Houston, Texas	Rotary, gas-gaso	1000	11,500
Franklin County			
Big Chief Drlg. Co.			
Box 8837, Oklahoma City, Okla.	Rotary, gas-gaso	1350	16,000
Gaines County			
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, steam		15,000
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	1200	15,000
	Rotary, gas-gaso	1260	15,000
Hamman Oil & Refining Co.			
Box 13028, Houston, Texas	Rotary, diesel	310	6000
Helmerich & Payne, Inc.			
First National Bldg., Tulsa, Okla.	Rotary, gas-gaso	1300	13,000
	Rotary, gas-gaso	1450	15,000
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.,			
Tulsa, Okla.	Rotary, gas-gaso	1150	14,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	732	10,000
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	660	7000
	Rotary, gas-gaso	1680	14 000
	Rotary, gas-gaso	1120	11,000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	1350	15,000
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, gas-gas	100	1500
	Rotary, gas-gas	100	1500
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, gas-gaso	775	9500
Galveston County			
Carnes W. Weaver Drlg. Co.			
326 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	900	11,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas or butane	1230	10,000
C. B. Webster Drlg. Co.			
609 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	500	8000
Galveston County (Offshore)			
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, diesel	1275	14,000
Garza County			
Graham Drillers, Inc.			
908 McBurnett Bldg., San Angelo, Tex.	Rotary, diesel	270	5000
LouSamBob Drlg. Co.			
1312 Main, Lubbock, Texas	Rotary, diesel	175	5000
	Rotary, diesel	145	3000
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Cable tool, gas-gaso	165	4000
	Cable tool, gas-gaso	185	5000
Glasscock County			
Donnell Drlg. Co.			
607 Texas Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	650	8000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Goliad County			
Holmes Drlg. Co.			
1045 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	700	10,000
McKensie Drlg. Co.			
717 Wilson Bldg., Corpus Christi, Tex.	Rotary, gas-gaso	180	5100
Grady County			
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	213	5000
Gonzales County			
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, diesel	290	3500
Gray County			
Cree Drlg. Co., Inc.			
Hughes Bldg., Pampa, Texas	Rotary, gas	350	4500
Grayson County			
Alan Drlg. Co.			
820 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	870	9000
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	145	4000
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, gas-gaso	750	9500
	Rotary, gas-gaso	750	9500
	Rotary, steam		15,000
	Rotary, steam		10,000
	Rotary, gas-gaso	1050	14,000
	Rotary, diesel	900	11,000
Empire Drlg. Co.			
1507 Mercantile Bk. Bldg., Dallas, Tex.	Rotary, gas-gaso	1000	14,000
Fleeger-Riley Drlg. Co., Inc.			
271 Meadows Bldg., Dallas, Texas	Rotary, diesel	600	8500
Frazier & Goble Drlg. Co.			
Box 68, Nocona, Texas	Rotary, diesel	300	5000
O. E. Hall Drlg. Co.			
1809 Electric Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1000	12,000
	Rotary, gas-gaso	700	8000
Gibson & Holliman			
1021 Fidelity Union Life Bldg.,			
Dallas, Texas	Rotary, gas-gaso	950	10,000
	Rotary, diesel	1000	12,000
	Rotary, gas-gaso	650	8500
	Rotary, gas-gaso	950	10,000
Helmerich & Payne, Inc.			
First National Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	10,000
Morris & Hamilton, Inc.			
1521 Commerce Bldg., Houston, Tex.	Rotary, gas-gaso	1300	14,000
	Rotary, gas-gaso	1150	12,000
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	600	9000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas or butane	1170	10,000
	Rotary, diesel	600	9000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	1350	15,000
	Rotary, gas-butane	1200	12,000
Gregg County			
Robert M. Bass			
Box 471, Kilgore, Texas	Rotary, gas-gaso	750	9000
Carter-Jones Drlg. Co.			
Box 1597, Kilgore, Texas	Rotary, gas-gaso	350	6800
South States Drlg. Co.			
Box 147, Longview, Texas	Rotary, diesel	350	8000
Hansford County			
Baker & Taylor Drlg. Co.			
712 First Natl. Bk. Bldg.,			
Amarillo, Texas	Rotary, gas	450	5500
	Rotary, diesel	600	8500
	Rotary, diesel	600	8000
Cree Drlg. Co., Inc.			
Hughes Bldg., Pampa, Texas	Rotary, gas	600	9000
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, gas-gaso	450	7500
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, diesel	928	9000
Hardin County			
Bass Drlg. Co.			
905 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	675	9000
Carnes W. Weaver Drlg. Co.			
326 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	700	10,000
Symons Drlg. Co.			
Box 546, Houston, Texas	Rotary, gas-gaso	550	8500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Harris County			
Blanton Drlg. Co.			
2030 Gulf Bldg., Houston, Texas	Rotary, diesel	600	9500
	Rotary, gas-gaso	700	8500
	Rotary, steam		12,000
	Rotary, gas-gaso	300	6000
Harry T. Bryant Drlg. Co., Ltd.			
3007 Buffalo Drive, Houston, Texas	Rotary, gas-gaso	800	10,000
	Rotary, gas-gaso	700	9000
Butler-Johnson, Inc.			
Box 306, Shreveport, La.	Rotary, gas-butane	900	11,000
Driscoll & Scott Drlg. Corp.			
Box 8133, Dallas, Texas	Rotary, butane	600	10,000
Amarillo, Texas			
Henderson Drlg. Corp.			
2208 Niels Esperson Bldg.,			
Houston, Texas	Rotary, gas-gaso	370	7000
	Rotary, gas-gaso	450	8500
	Rotary, gas-gaso	700	11,000
Liberty Drlg. Corp.			
Box 14308, Houston, Texas	Rotary, gas-gaso	675	9000
Meredith & Co.			
1027 Pioneer American Bldg.			
Houston, Texas	Rotary, gas-gaso	680	9500
Taylor Exploration Co., Inc.			
2118 Welch Ave., Houston, Texas	Rotary, gaso		1400
Union of Texas Oil Co.			
565 San Jacinto Bldg., Houston, Tex.	Rotary, diesel	320	6500
Harrison County			
Ed E. Hurley, Successor			
Shreveport, La.	Rotary, gas-gaso	750	10,000
Hartley County			
Kerr-McGee Oil Industries, Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	832	10,000
Haskell County			
Ace Drlg. Co.			
1800 Republic Natl. Bk. Bldg.			
Dallas, Texas	Rotary, gas-gaso	680	7500
Ray Smith Drlg. Co.			
Simons Bldg., Dallas, Texas	Rotary, gas-gaso	350	7500
Henderson County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	600	8000
Halbert Drlg. Co.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	250	5500
Maxwell Herring Drlg. Corp.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	175	4000
Hidalgo County			
Buzzini Drlg. Co.			
541 Milam Bldg., San Antonio, Tex.	Rotary, gas-butane	960	11,000
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary, diesel	265	6000
	Rotary, gas-gaso	675	8500
Longhorn Drlg. Corp.			
Three Rivers, Texas	Rotary, gas-butane	675	9000
Hockley County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	800	9000
	Rotary, gas-gaso	1125	15,000
Keating Drlg. Co.			
510 Natl. Bk. of Tulsa Bldg.			
Tulsa, Okla.	Rotary, gas-gaso	450	6500
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, gas-gaso	675	9500
Hopkins County			
Gibson Drlg. Co.			
Box 214, Kilgore, Texas	Rotary, gas-gaso	250	6000
Houston County			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Texas	Rotary, diesel	700	11,000
Howard County			
A. D. Engle & Co.			
Big Spring, Texas	Cable tool, gas-butane	145	8000
	Cable tool, gas-butane	145	8000
Graham Drlg. Co.			
916 Staley Bldg., Wichita Falls, Tex.	Rotary, diesel	200	5000
Sheets & Walton Drlg. Co.			
Box 152, Breckenridge, Texas	Rotary, butane	225	500
	Rotary, butane	225	500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Hutchinson County			
Cree Drlg. Co., Inc.			
Hughes Bldg., Pampa, Texas	Rotary, gas	300	4500
	Rotary, gas	280	4500
	Rotary, gas	280	4000
	Rotary, gas	300	5000
Drilling & Exploration Co. of Delaware, Inc.			
Union Oil Bldg., Midland, Texas	Rotary, gas-gaso	300	5000
	Rotary, gas-gaso	300	5000
J. R. McGill			
509 Amarillo Bldg., Amarillo, Texas	Rotary, gas-gaso	570	7000
	Cable tool, gas-gaso	145	4000
	Cable tool, gas-gaso	145	4000
Irion County			
R-H-K Drlg. Co., Ltd.			
111 Wagstaff Bldg., Abilene, Texas	Rotary, gas-gaso	675	10,000
Jack County			
Alan Drlg. Co.			
820 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	225	4500
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	185	4000
Leatherwood Drlg. Co.			
Box 925, Jacksboro, Texas	Rotary, diesel	350	6000
	Rotary, diesel	350	6000
Rankin, Karper & Glass			
Box 149, Graham, Texas	Rotary, diesel	500	7500
Jackson County			
Kirkwood & Morgan, Inc.			
204 Transit Tower, San Antonio, Tex.	Rotary, diesel	450	5000
Jeff Davis County			
Makin Drlg. Co.			
Box 1628, Hobbs, N. M.	Rotary, gas-gaso	975	12,000
Jefferson County			
Bass Drlg. Co.			
905 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	675	9000
Clegg & Hunt			
715 Houston Club Bldg., Houston, Tex.	Rotary, steam	.....	15,000
	Rotary, tseam	.....	11,000
Lake Drlg. Co.			
1417 Church, Beaumont, Texas	Rotary, gas-gaso	200	5500
C. B. Webster Drlg. Co.			
609 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	1000	12,000
Jim Wells County			
Appell Drlg. Co.			
Box 330, Alice, Texas	Rotary, diesel	400	7000
	Rotary, gas-gaso	150	4000
Flournoy Drlg. Co.			
Box 1578, Alice, Texas	Rotary, gas-gaso	320	7000
Layton Brown Drlg. Co.			
Box 4, Woodsboro, Texas	Rotary, gas-gaso	400	6500
Longhorn Drlg. Corp.			
Three Rivers, Texas	Rotary, steam	.....	10,000
Pyramid Drlg. Co.			
Box 1049, Alice, Texas	Rotary, gas-butane	165	6200
	Rotary, gas-butane	165	6200
Jones County			
Ace Drlg. Co.			
1800 Republic Natl. Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	680	7500
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	145	3500
Dugger & Herring Drlg. Co.			
224 Petroleum Bldg., Abilene, Texas	Rotary, gas-gaso	500	8500
	Rotary, diesel	400	7500
Lamar H. Moore Drlg. Co.			
Box 29, Abilene, Texas	Rotary, gas-gaso	480	7500
West Central Drlg. Co.			
617 F & M Bk. Bldg., Abilene, Tex.	Cable tool, gas-gaso	200	4000
Kannes County			
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, gas-gaso	675	9000
Kaufman County			
Ace Drlg. Co.			
1800 Republic Natl. Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	680	7500
Gibson Drlg. Co.			
Box 214, Kilgore, Texas	Rotary, gas-gaso	138	4000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Kennedy County			
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary-barge, diesel	900	13,000
Kent County			
Edgar Davis Drlg. Co.			
617 F & M Bk. Bldg., Abilene, Tex.	Rotary, gas-gaso	750	12,000
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	500	9000
Kleberg County			
Holmes Drlg. Co.			
1045 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	1500	16,000
Knox County			
CB Drlg. Co.			
Oklahoma City, Okla.	Rotary, gas-gaso	450	8000
Leon County			
Robert M. Bass			
Box 471, Kilgore, Texas	Rotary, steam	500	12,000
Mustang Drlg. Corp.			
1201 Peoples Bk. Bldg., Tyler, Texas	Rotary, gas-gaso	350	6000
Liberty County			
Carnes W. Weaver Drlg. Co.			
326 Gulf Bldg., Houston, Texas	Rotary, gas-gaso	700	10,000
Liberty Drlg. Corp.			
Box 14308, Houston, Texas	Rotary, gas-gaso	450	8500
Live Oak County			
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, gas-gaso	675	9000
Longhorn Drlg. Corp.			
Three Rivers, Texas	Rotary, gas-butane	1000	12,000
Mangum Drlg. Co.			
834 Esperson Bldg., Houston, Texas	Rotary, steam	.....	11,000
Loving County			
McDaniel & Beecherl Drlg. Co.			
607 Davis Bldg., Dallas, Texas	Rotary, gas-gaso	425	5000
Urice Drlg. Co.			
615 Ft. Worth Club Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	700	9000
Lubbock County			
Thompson Exploration Drlg. Co.			
Box 1657, Lubbock, Texas	Rotary, diesel	290	3500
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, diesel	660	8500
	Cable tool, gas-gaso	185	5000
Matagorda County			
Brewster-Bartle Drlg. Co., Inc.			
1912 Esperson Bldg., Houston, Tex.	Rotary, steam	.....	12,000
Hamman Oil & Refining Co.			
Box 13028, Houston, Texas	Rotary, steam	.....	12,000
Morris & Hamilton, Inc.			
1521 Commerce Bldg., Houston, Tex.	Rotary, gas-gaso	1800	22,000
Pernie Bailey Drlg. Contr.			
2309 Sage Rd., Houston, Texas	Rotary, gas-gaso	850	10,000
Salt Dome Production Co.			
1900 Mellie Esperson Bldg.,			
Houston, Texas	Rotary, diesel	1000	12,000
Maverick County			
Rock Hill Drlg. Co.			
704 Milam Bldg., San Antonio, Tex.	Rotary, diesel	550	8000
Rowan Drlg. Co., Inc.			
19th Floor Fair Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	1480	15,000
McMullen County			
Longhorn Drlg. Corp.			
Three Rivers, Texas	Rotary, steam	.....	15,000
Medina County			
Pegg Brothers Drlg. Co.			
1204 Natl. Bk. of Commerce Bldg.,			
San Antonio, Texas	Rotary, gas-gaso	110	3000
Midland County			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	900	15,000
Frawley Drlg. Co.			
823 S. Detroit, Tulsa, Okla.	Rotary, gas-gaso	1000	13,000
Helmerich & Payne, Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	13,000
Llano Drlg. Co.			
301 V & J Tower, Midland, Texas	Rotary, gas-gaso	975	15,000
	Rotary, diesel	1200	18,000
	Rotary, diesel	1200	18,000
Lowe Drlg. Co.			
Box 832, Midland, Texas	Rotary, gas-gaso	1800	18,000
	Rotary, gas-gaso	700	8500

Get greater profits
starting with your next fracture job

Adomite*

Adomite is a revolutionary fluid-loss control additive for converting lease crudes to superior fracturing fluids. It has already been used successfully in over 1,000 fracture jobs in different fields.

Ask your service company to use Adomite on your next fracture job

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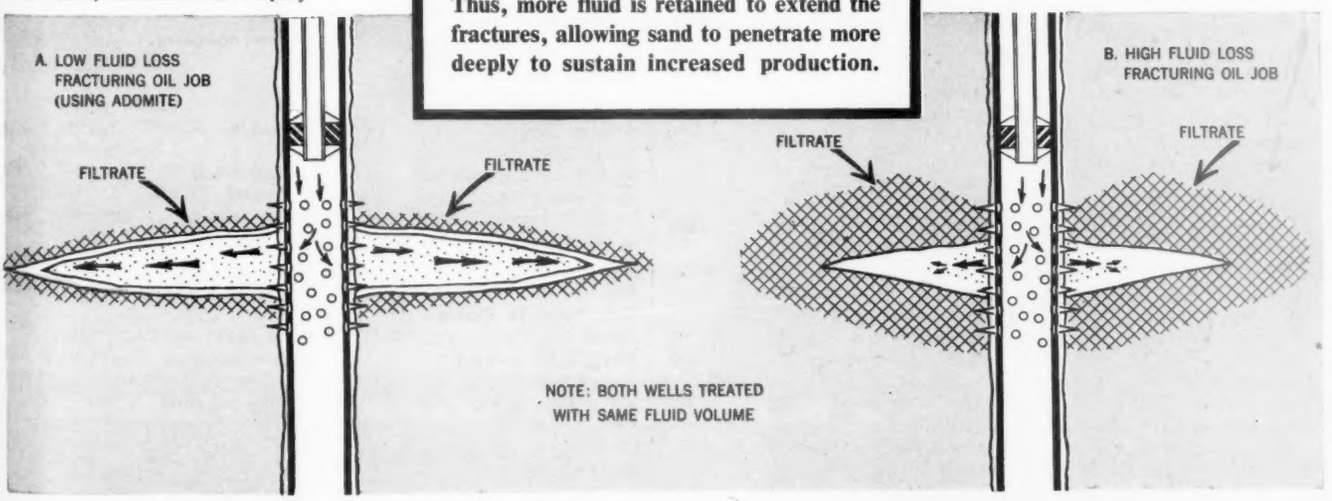
HOW ADOMITE BENEFITS PRODUCERS

- Effectively seals the fracture face and practically prevents loss of fluid into the producing formation.
- Results in longer fractures and deeper penetration of sand for a given job.
- Cleans up rapidly. Does not contaminate the produced oil or the formation.
- Greater sustained production with a given fluid volume at lower cost.
- Equally effective in oils which have or have not been treated with emulsion breakers.
- Easy to use. Adomite is a dry material in flake form. It is mixed directly into the crude or gelled crudes on the lease, using only standard mixing equipment.

HOW IT WORKS

Adomite retards fluid loss into the formation. Thus, more fluid is retained to extend the fractures, allowing sand to penetrate more deeply to sustain increased production.

*Trade-mark, Continental Oil Company


A. LOW FLUID LOSS FRACTURING OIL JOB (USING ADOMITE)
FILTRATE
FILTRATE
B. HIGH FLUID LOSS FRACTURING OIL JOB
FILTRATE
FILTRATE
NOTE: BOTH WELLS TREATED WITH SAME FLUID VOLUME

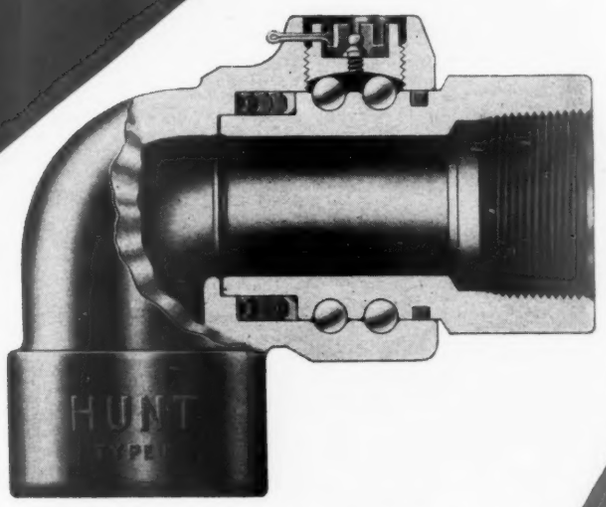
Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Zephyr Drlg. Corp.			
1111 First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1350	20,000
	Rotary, steam	.....	16,000
	Rotary, gas-gaso	1400	20,000
Mitchell County			
Dual Drlg. Co.			
1111 City Natl. Bk. Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	700	11,000
Miami Operating Co., Inc.			
Drawer 2040, Abilene, Texas	Rotary, gas	650	7000
	Rotary, gas	650	7000
Montague County			
O. E. Hall Drlg. Co.			
1809 Electric Bldg., Ft. Worth, Texas	Rotary, gas-gaso	700	8000
Leatherwood Drlg. Co.			
Box 925, Jacksboro, Texas	Rotary, gas-gaso	500	7000
W. B. Omohundro			
102 Oil Center, Wichita Falls, Tex.	Rotary, butane	450	6500
Montgomery County			
Bass Drlg. Co.			
905 San Jacinto Bldg., Houston, Tex.	Rotary, gas-gaso	225	6000
Driscoll & Scott Drlg. Corp.			
Box 8133, Dallas, Texas	Rotary, butane, n.g.	200	6500
Mangum Drlg. Co.			
834 Esperson Bldg., Houston, Tex.	Rotary, gas-gaso	450	6500
Navarro County			
Carter-Jones Drlg. Co.			
Box 1597, Kilgore, Texas	Rotary, gas-gaso	300	6500
Ficklin Drlg. Co.			
Box 1239, Corsicana, Texas	Rotary, gas-gaso	300	4500
	Rotary, gas-gaso	110	1200
Nolan County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	560	7000
Blount Drlg.			
114 Central Bldg., Midland, Tex.	Rotary, gas-gaso	675	8500
Brannon & Murray Drlg. Co.			
Coleman Natl. Bk. Bldg.,			
Coleman, Texas	Rotary, gas-gaso	530	8000
Dual Drlg. Co.			
1111 City Natl. Bk. Bldg.,			
Wichita Falls, Texas	Rotary, diesel	600	6500
	Rotary, gas-gaso	600	7000
Empire Drlg. Co.			
1507 Mercantile Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	750	10,000
Foree-Thomas Drlg. Co.			
602 1st Natl. Bk. Bldg., Dallas, Tex.	Rotary, gas-gaso	750	7500
General Geophysical Co.			
750 Houston Club Bldg., Houston, Tex.	Rotary, diesel	500	7500
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	630	7500
Moore & Moore Drlg. Co.			
Box 29, Abilene, Texas	Rotary, gas-gaso	636	7500
	Rotary, gas-gaso	185	5500
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	600	9000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, gas or butane	756	10,000
R-H-K Drlg. Co., Ltd.			
111 Wagstaff Bldg., Abilene, Texas	Rotary, gas-gaso	555	7500
	Rotary, gas-gaso	740	7500
Rheay & Reynolds Drlg. Co.			
404 Petroleum Bldg., Abilene, Tex.	Rotary, gas-gaso	675	7500
	Rotary, gas-gaso	675	7500
Nueces County			
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary-barge, diesel	600	8500
	Rotary-barge, diesel	1100	14,000
Burdette Graham			
804 Driscoll Bldg.,			
Corpus Christi, Texas	Rotary, gas-gaso	738	10,000
	Rotary, gas-gaso	780	10,000
Frio Drlg., Inc.			
506 Driscoll Bldg., Corpus Christi, Tex.	Rotary, gas-gaso	600	7000
Longhorn Drlg. Corp.			
Three Rivers, Texas	Rotary, gas-butane	675	9000
Rock Hill Drlg. Co.			
704 Milam Bldg., San Antonio, Tex.	Rotary, diesel	550	8000

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Ochiltree County			
Baker & Taylor Drlg. Co.			
712 1st Natl. Bk. Bldg., Amarillo, Tex.	Rotary, gas	1200	11,000
	Rotary, diesel	600	8500
	Rotary, gas	900	14,000
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	750	10,000
Orange County			
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel-barge (rigging up)	1500	18,000
Panola County			
Maxwell Herring Drlg. Corp.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	800	10,000
Tex-Mex Drlg. Co.			
1211 Fidelity Union Life Bldg.,			
Dallas, Texas	Rotary, steam		10,000
Pecos County			
Blount Drlg.			
114 Central Bldg., Midland, Texas	Rotary, gas-gaso	700	9000
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	500	7000
O'Neal Drlg. Co.			
1314 Oil & Gas Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	700	11,000
Penrod Drlg. Co.			
418 Market, Shreveport, La.	Rotary, diesel	1460	15,000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	900	10,000
Reagan County			
Arrow Drlg. Co.			
407 Philtower Bldg., Tulsa, Okla.	Rotary, gas-gaso	840	10,000
Robert M. Bass			
Box 471, Kilgore, Texas	Rotary, gas-gaso	500	7000
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	1050	15,000
Donnell Drlg. Co.			
607 Texas Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	650	10,000
Carl B. King Drlg. Co. of Texas			
Box 270, Midland, Texas	Rotary, gas-gaso	1000	12,500
Llano Drlg. Co.			
301 V & J Tower, Midland, Texas	Rotary, gas-gaso	700	11,000
Warton Drlg. Co.			
Box 2807, Odessa, Texas	Rotary, gas-gaso	1100	14,000
Refugio County			
J & C Drlg. Co.			
Box 552, Refugio, Texas	Rotary, steam		8500
Kelley Brothers			
Box 121, Refugio, Texas	Rotary, gas-gaso	300	5500
The Oil Corp.			
520 Wilson Bldg., Corpus Chritsi, Tex.	Rotary, gas-gaso	300	6500
Rock Hill Drlg. Co.			
704 Milam Bldg., San Antonio, Tex.	Rotary, gas-gaso	475	6500
Roberts County			
Baker & Taylor Drlg. Co.			
712 First Natl. Bk. Bldg.,			
Amarillo, Texas	Rotary, gas	675	10,000
Schafer Drlg. Co.			
2400 Liberty Bk. Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	302	6000
Urice Drlg. Co.			
615 Ft. Worth Bldg.,			
Ft. Worth 2, Texas	Rotary, gas-gaso	560	8000
Runnels County			
Hack Drlg. Co.			
2601 Butternut, Box 1636,			
Abilene, Texas	Rotary, butane	161	4500
Miami Operating Co., Inc.			
Box 2040, Abilene, Texas	Rotary, diesel	350	4500
Varner-Neill Drlg. Co.			
1674 N. Treadaway, Abilene, Texas	Rotary, butane	450	7500
Rusk County			
Carter-Jones Drlg. Co.			
Box 1597, Kilgore, Texas	Rotary, gas-gaso	240	4000
San Patricio County			
Appell Drlg. Co.			
Box 330, Alice, Texas	Rotary, gas-gaso	225	5500
Conroe Drlg. Co.			
307 Wilson Tr., Corpus Christi, Tex.	Rotary, gas-gaso	900	10,000
J & C Drlg. Co.			
Box 552, Refugio, Texas	Rotary, steam		10,000
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, steam		10,000

HUNT

FORGED STEEL SWIVELS

Heat treated forged steel body utilizes double ball principle—allows low torque under high pressure.



Type D 6,000 PSI WP @ 225° F, OWG. (color code aluminum).
Forged steel swivel joint recommended for OWG service.
Stocked in ¾" to 4" sizes, incl.

Type DS 500 PSI WP @ 600° F, HI-TEMP. (color code yellow).
Forged steel swivel joint. Recommended for HIGH TEMP. service.
Stocked in ¾" to 4" sizes, incl.

Type E 10,000# WP @ 225° F, CEMENT. (color code green)
Type E 15,000# WP @ 225° F, CEMENT. (color code red)
Forged steel swivel joint recommended for CEMENTING service. Stocked in 2" only.

Call your nearest Supply Store.

MUD CUBS
ALL-STEEL DRILLING HEAD
ALL-STEEL CEMENTING HEAD
ALL-STEEL CIRCULATING HEAD
FORGED STEEL SWIVEL JOINTS

HUNT TOOL COMPANY

GENERAL OFFICES AND PLANT: HOUSTON, TEXAS
Field Shops: Bay City & Corpus Christi, Texas; Jennings & Harvey, La.
Marine Division: Harvey, La.
Export Sales: Hunt Export Company, 19 Rector St., New York
Houston, Texas; Buenos Aires; Port of Spain; Caracas

FISHING TOOL SERVICE

A BUSINESS BUILT ON *Good* SERVICE

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Schleicher County			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	700	7000
Wes-Tex Drlg. Co.			
308 Petl. Bldg., Abilene, Texas	Rotary, gas-gaso	380	6800
Scurry County			
Coroco Drlg. Co.			
2807 Mercantile Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	500	9000
Frawley Drlg. Co			
823 S. Detroit, Tulsa, Okla.	Rotary, gas-gaso	750	8000
Shackleford County			
The Herb Exploration Co.			
342 Lexington Ave., Abilene ,Texas	Roary, gas-gaso	.....	1500
West & Honea			
Box 65, Stamford, Texas	Cable tool, gas-gaso	65	1600
Smith County			
Gibson Drlg. Co.			
Box 214, Kilgore, Texas	Rotary, gas-gaso	226	4500
Liberty Drlg. Corp.			
Box 14308, Houston 21, Texas	Rotary, gas-gaso	450	8500
Maxwell Herring Drlg. Corp.			
Box 1122, Kilgore, Texas	Rotary, gas-gaso	300	5500
Penrod Drlg. Co.			
418 Market St., Shreveport, La.	Rotary, steam	.....	15,000
Starr County			
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, gas-gaso	675	9000
L & W Drlg. Co.			
Box 609, Mission, Texas	Rotary, gas-butane	375	5500
	Rotary, gas-butane	485	7500
Stephens County			
Edwards Drlg. Co.			
Box 1140, Graham, Texas	Rotary, gas-gaso	500	7500
Oney Drlg. Co.			
ox 425, Graham, Texas	Cable tool, gas-gaso	145	4500
Sterling County			
Foree-Thomas Drlg. Co.			
602 1st Nat. Bk. Bldg., Dallas, Texas	Rotary, gas-gaso	750	7500
	Rotary, gas-gaso	750	7500
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	900	10,500
Stonewall County			
Empire Drlg. Co.			
1507 Mercantile Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	650	8500
Hack Drlg. Co.			
Box 1636, Abilene, Texas	Rotary, butane	412	8500
Rheay & Reynolds Drlg. Co.			
404 Petroleum Bldg., Abilene, Texas	Rotary, gas-gaso	675	7500
J. B. Schick Drlg. Co.			
510 Petroleum Bldg., Abilene, Texas	Rotary, diesel	300	7000
Wes-Tex Drlg. Co.			
308 Petl. Bldg., Abilene, Texas	Rotary, gas-gaso	290	6500
Sutton County			
M. J. Delaney Co.			
512 Continental Bldg., Dallas, Texas	Rotary, gas-gasc	450	7000
Taylor County			
Cannon Drlg. Co.			
214 Petroleum Bldg., Abilene, Texas	Rotary, diesel	225	4500
	Rotary, diesel	225	4000
Hack Drlg. Co.			
Box 1636, Abilene, Texas	Rotary, butane	161	2500
Jones Well Serv. Co.			
Box 1547, Abilene, Texas	Cable tool, gas-gaso	175	3500
	Cable tool, gas-gaso	175	3500
	Cable tool, gas-gaso	175	3500
R-H-K Drlg. Co., Ltd.			
111 Wagstaff Bldg., Abilene, Texas	Rotary, gas-gaso	555	7500
J. B. Schick Drlg. Co.			
510 Petroleum Bldg., Abilene, Texas	Rotary, gas-gaso	300	5000
Tex-Ace Drlg. Co.			
Abilene, Texas	Rotary, gas-gaso	200	4000
	Cable tool, gas-gaso	200	4000
Wes-Tex Drlg. Co.			
308 Petl. Bldg., Abilene, Texas	Rotary, diesel, gas-gaso	280	5500
West Central Drlg. Co.			
617 F & M Bk. Bldg., Abilene, Texas	Rotary, gas-gaso	600	6000
	Rotary, gas-gaso	300	2500

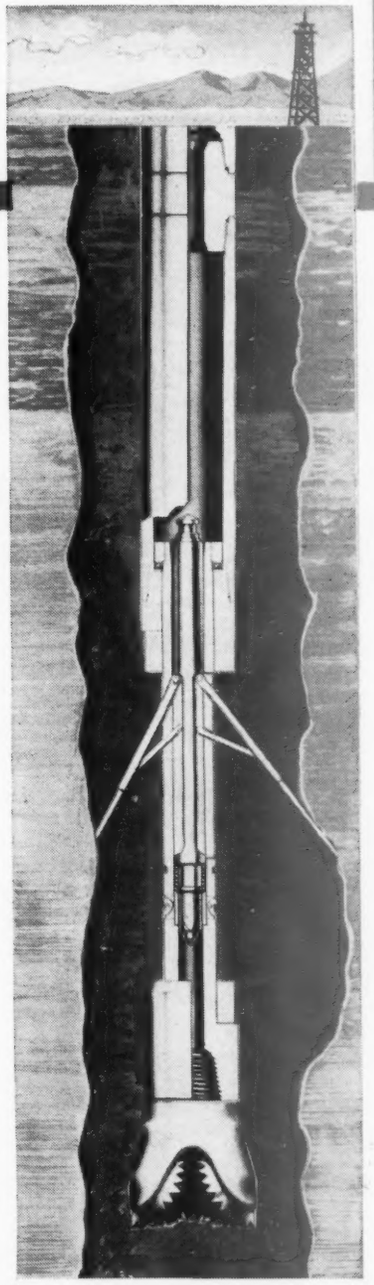
Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Terry County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	840	9000
	Rotary, diesel	750	7500
	Rotary, diesel	750	7500
	Rotary, gas-gaso	675	7500
	Rotary, gas-gaso	675	7500
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla.	Rotary, gas-gaso	1100	13,000
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	1050	12,500
Penrod Drlg. Co.			
418 Market St., Shreveport, La.	Rotary, gas or butane	820	9000
Sharp Drlg. Co.			
Box 1271, Midland, Texas	Rotary, gas-butane	1350	16,000
Throckmorton County			
R-G Drlg. Co.			
403 City Natl. Bk. Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	650	8000
	Rotary, gas-gaso	450	6500
W. H. Varner Drlg. Co.			
1670 N. Treadaway Blvd.,			
Abilene,, Texas	Cable tool, gaso	75	2000
Tom Green County			
Robert M. Bass			
Box 471, Kilgore, Texas	Rotary, gas-gaso	600	8000
Delaware Drillers Inc.			
204 Chadbourne Bldg.,			
San Angelo, Texas	Rotary, butane-gas	675	8000
O'Neal Drlg. Co.			
1314 Oil & Gas Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	675	10,000
R-H-K Drlg. Co., Ltd.			
111 Wagstaff Bldg., Abilene, Texas	Rotary, gas-gaso	555	7500
Ray Smith Drlg. Co.			
3rd Floor Simons Bldg., Dallas, Texas	Rotary, gas-gaso	300	7000
Upton County			
Penrod Drlg. Co.			
418 Market St., Shreveport, La.	Rotary, gas or butane	1230	12,000
	Rotary, diesel	1464	14,000
	Rotary, gas or butane	1500	15,000
	Rotary, diesel	1050	10,000
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth Texas	Rotary, gas-gaso	1149	11,000
Triangle Drlg. Co.			
McCamey, Texas	Cable tool, butane	215	8500
	Cable tool, butane	82	2500
Val Verde County			
Delta Gulf Drlg. Co.			
Box 2012, Tyler, Texas	Rotary, gas-gaso	800	9000
Victoria County			
Field Drlg. Co.			
1409 Milam Bldg., San Antonio, Tex.	Rotary, diesel	520	9000
J & C Drlg. Co.			
Box 552, Refugio, Texas	Rotary, diesel, gas	700	8500
	Rotary, gas-butane	750	12,500
	Rotary, gas-butane	600	7500
	Rotary, diesel	750	12,500
	Rotary, steam	.....	14,000
John Haseman, Inc.			
439 Wilson Bldg.,			
Corpus Christi, Texas	Rotary, gas-gaso	300	6000
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, diesel	600	8500
Neal Drlg. Co.			
Box 423, Victoria, Texas	Rotary, gas-gaso	560	9500
Ward County			
Art West Drlg. Co.			
Box 1545, Odessa, Texas	Cable tool, gas	145	8000
	Cable tool, gas	145	8000
	Cable tool, gas	145	8000
	Cable tool, gas	145	5500
Brantly Drlg. Co.			
109 Capitol Bldg., Midland, Texas	Rotary, gas	500	9000
Coroco Drlg. Co.			
2807 Marcantile Bk. Bldg.,			
Dallas, Texas	Rotary, gas-gaso	650	12,500
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	630	7500

"Like getting the hole calipered FREE!"

...as a driller said recently.

Here's why no other caliper can match the

Johnston Hydraulic HOLE CALIPER



The Johnston Hydraulic Caliper provides accurate information on hole diameter from bottom to top. Information you can use with confidence.

Whatever the hole condition, you can be sure of getting a complete picture with the Johnston Hydraulic Caliper!

Saves time! No need to stop and rig up wire line. No delay or difficulty in crooked or directionally drilled holes.

Saves money! The *only* hole caliper that can often pay the cost of calipering in savings in rig time. The Johnston Hydraulic Hole Caliper is dropped into the drill pipe just before pipe is removed. Measures and records hole diameter as pipe is pulled from hole. Pipe may be rotated out in normal manner.

Accurate! Records continuous diameter of hole, bottom to top, either at detail speed or normal charting speed. Each measuring arm functions independently assuring the accurate measurement of irregular shaped hole.

Measures from the bottom! With the Johnston Hydraulic Hole Caliper, you can always be sure of starting to measure at the bottom every time.

When you get so many more advantages by using the Johnston Hydraulic Hole Caliper, why ever use less?

WRITE OR CALL FOR DESCRIPTIVE FOLDER

JOHNSTON TESTERS

first in drill stem testing

FORMATION AND CASING TESTING — JOHNSTON

P.O. BOX 98,
HOUSTON, TEXAS
LOS ANGELES, CALIF. • CALGARY, CAN.

HC 551

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Hatfield Drlg. Co., Inc.			
1611 N. H., Midland, Texas	Cable tool, gas-gaso	120	8500
	Cable tool, gas-gaso	100	5000
	Cable tool, diesel	120	8500
O'Neal Drlg. Co.			
1314 Oil & Gas Bldg., Ft. Worth, Tex.	Rotary, gas-gaso	450	6500
Wharton County			
Mac Drlg. Co.			
Box 2972, Houston, Texas	Rotary, steam		10,000
Wichita County			
R-G Drlg. Co.			
403 City Natl. Bk. Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	650	8000
Red River Drlg. Co.			
402 Hamilton Bldg.,			
Wichita Falls, Texas	Rotary, diesel	180	3200
Harold Shappell			
510 City Natl. Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	135	2700
Tex-State Oil			
427 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	145	4000
Wilbarger County			
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	276	6500
Willacy County			
C. G. Glasscock Drlg. Co.			
1601 Wilson Tower,			
Corpus Christi, Texas	Rotary, diesel	800	11,000
Kirkwood & Co.			
Box 1490, Alice, Texas	Rotary, gas-gaso	555	8000
Wilson County			
Buzzini Drlg. Co.			
541 Milam Bldg., San Antonio, Texas	Rotary, gas butane	200	4000
Kirkwood & Morgan, Inc.			
204 Transit Tower, San Antonio, Tex.	Rotary, diesel	450	6000
Pegg Brothers Drlg. Co.			
1204 Natl. Bk. of Com. Bldg.,			
San Antonio, Texas	Rotary, gas-gaso	90	1500
	Rotary, gas-gaso	145	4500
Sutton Drlg. Co.			
4600 Broadway, San Antonio, Texas	Rotary, gas-gaso	125	1500
	Rotary, diesel	225	3500
Travis Drillers, Inc.			
202 W. 1st St., Austin, Texas	Rotary, gas-gaso	145	3500
Winkler County			
Blount Drlg.			
114 Central Bldg., Midland, Texas	Rotary, gas-gaso	175	4500
Donnell Drlg. Co.			
607 Texas Bk. Bldg., Dallas, Texas	Cable tool, gas-gaso		5000
	Cable tool, gas-gaso		5000
	Cable tool, gas-gaso		5000
O'Neal Drlg. Co.			
1314 Oil & Gas Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	200	5500
Wise County			
CB Drlg. Co.			
Oklahoma City, Okla.	Rotary, gas-gaso	450	8000
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	450	7500
Leatherwood Drlg. Co.			
Box 925, Jacksboro, Texas	Rotary, gas-gaso	500	7000
	Rotary, gas-gaso	750	10,000
Norwood Drlg. Co.			
Wichita Falls, Texas	Rotary, gas-gaso	600	8500
Walters Drlg. Co., Inc.			
4114 McMillan, Dallas, Texas	Rotary, gas		600
	Rotary, gas		600
Wood County			
Gibson Drlg. Co.			
Box 214, Kilgore, Texas	Rotary, gas-gaso	145	5000
South States Drlg Co.			
Box 147, Longview, Texas	Rotary, diesel	350	10,000
Yoakum County			
Davidson Drlg. Co., Inc.			
1004 Continental Life Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	500	7000
	Rotary, gas-gaso	1200	14,000
The Eastland Oil Co.			
806 Continental Life Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	190	4500
	Rotary, gas-gaso	200	4500
	Cable tool, gas-gaso	175	4000
Helmerich & Payne Inc.			
First Natl. Bldg., Tulsa, Okla	Rotary, gas-gaso	1100	13,000
Llano Drlg. Co.			
301 V & J Tower, Midland, Texas	Rotary, gas-gaso	1050	15,000
O'Neal Drlg. Co.			
1314 Oil & Gas Bldg.,			
Ft. Worth, Texas	Rotary, gas-gaso	200	5500
Rowan Drlg. Co., Inc.			
19th Fl. Fair Bldg., Ft. Worth, Texas	Rotary, gas-gaso	1149	11,000
Art West Drlg. Co.			
Box 1545, Odessa, Texas	Cable tool, gas	145	8000
Western Drlg. Co., Inc.			
902 Lubbock Natl. Bk. Bldg.,			
Lubbock, Texas	Rotary, diesel	495	6500
Young County			
Bolin Oil Co.			
1120 Oil & Gas Bldg.,			
Wichita Falls, Texas	Rotary, gas-gaso	225	5000
Oney Drlg. Co.			
Box 425, Graham, Texas	Cable tool, gas-gaso	180	4500
	Cable tool, gas-gaso	160	4500
Rankin, Karper & Glass			
Box 149, Graham, Texas	Rotary, gas	175	3500
	Rotary, diesel	300	5000
	Rotary, diesel	400	7000
Schulz & Brannan Drlg. Co.			
621 Staley Bldg., Wichita Falls, Texas	Rotary, diesel	200	5000
Turner & West			
Box 65, Stamford, Texas	Rotary, butane	200	4500
UTAH			
Carbon County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, gas-gaso	450	5000
Grand County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	600	5500
San Juan County			
Great Western Drlg. Co.			
509 N. Loraine, Midland, Texas	Rotary, diesel	600	5500
	Rotary, diesel	500	6500
Jet Drlg. Co., Inc.			
710 17th St., Denver, Colo.	Rotary, diesel	900	10,000
George Noland Drlg. Co., Inc.			
823 S. Detroit Ave., Tulsa, Okla.	Rotary, gas-butane	730	8500
	Rotary, gas-butane	730	8500
R. W. Rine Drlg. Co.			
520 Central Bldg., Wichita, Kan.	Rotary, diesel	600	8500
Uintah County			
Kerr-McGee Oil Industries Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	818	11,000
	Rotary, gas-gaso	556	8000
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	1800	15,000
Utah County			
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, gas-gaso	600	7500
WEST VIRGINIA			
Logan County			
Allen Drlg. Co.			
4410 Venable Ave.,			
Charleston, W. Va.	Cable tool, gas	200	5000
	Cable tool, gaso	200	5000
	Cable tool, gas	200	5000
Mingo County			
Allen Drlg. Co.			
4410 Venable Ave.,			
Charleston, W. Va.	Cable tool, gas	200	5000
	Cable tool, gas	200	5000
	Cable tool, gaso	200	5000
Tyler County			
Henry Gwaltney Drlg. Co.			
State Bk. Idg., Washington, Ind.	Rotary, gas-gaso	200	3000
WYOMING			
Big Horn County			
Clark Drlg. Co.			
Box 1743, Billings, Mont.	Rotary, diesel or gas-gaso	300	5000
	Rotary, diesel	300	3500
	Rotary, diesel or gas-gaso	750	7500

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, gas-butane	440	6500
	Rotary hi-line electric	200	6500
Campbell County			
Black Hills Drlg. Co., Inc.			
Newcastle, Wyo.	Rotary, diesel	450	8000
J. D. Sprecher Drlg. Contractor			
Box 299, Casper, Wyo.	Rotary, diesel	900	10,000
Carbon County			
A. O. Bullock Drlg. Co.			
Box 821, Casper, Wyo.	Rotary, gas	200	5000
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, diesel	560	8500
Charles M. Jameson			
3366 S. Broadway, Englewood, Colo.	Cable tool, gas-gaso	150	4000
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, gas-butane	1125	11,000
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel	520	7500
Converse County			
Dyer Drlg. Co.			
Box 338, Casper, Wyo.	Rotary, gas-gaso	480	7000
Fremont County			
George Noland Drlg. Co., Inc.			
823 S. Detroit Ave., Tulsa, Okla.	Rotary, gas-butane	730	8500
	Rotary, gas-butane	440	5000
Ainsworth, Inc.			
1002 Union Natl. Bk. Bldg.,			
Wichita, Kan.	Rotary, gaso	100	3000
Brack Drlg., Co., Inc.			
Box 575, Fort Collins, Colo.	Rotary, diesel	254	5500
Lohmann-Johnson Drlg. Co., Inc.			
320 Indiana Bk. Bldg.,			
Evansville, Ind.	Cable tool, gas	165	10,000
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, gas-butane	1305	14,000
	Rotary, gas-butane	750	7000
Goshen County			
Miracle-Fifer Drlg. Co.			
1636 Welton St., Denver, Colo.	Rotary, butane	660	8500
Hot Springs County			
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, diesel	280	5500
	Rotary, gas-gaso	600	8500
Brack Drlg. Co., Inc.			
Box 575, Fort Collins, Colo.	Rotary, diesel	254	5500
Dyer Drlg. Co.			
Box 338, Casper, Wyo.	Rotary, gas-gaso	365	4500
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel	800	10,000
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, diesel	528	7000
Johnson County			
Signal Exploration Inc.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, gas-gaso	450	7000
Julesburg Basin			
Nye & Snell Drlg. Co.			
260 Denver Club Bldg., Denver, Colo.	Rotary, diesel	600	9000
Laramie County			
Nye & Snell Drlg. Co.			
260 Denver Club Bldg., Denver, Colo.	Rotary, diesel	300	5000
Natrona County			
A. O. Bullock Drlg. Co.			
Box 821, Casper, Wyo.	Rotary, gas	200	4000
Anschutz Drlg. Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, gas-gaso	600	8500
	Rotary, gas-gaso	600	8500
Arapahoe Drlg. Co.			
504 Colorado Bldg., Denver, Colo.	Rotary, gas-gaso	350	5500
Dyer Drlg. Co.			
Box 338, Casper, Wyo.	Rotary, diesel	300	3500
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	1200	12,500
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, diesel	550	7000
The New Drlg. Co.			
1018 Patterson Bldg., Denver, Colo.	Rotary, gas-gaso	900	9000
Park County			
Anschutz Drlg., Co., Inc.			
1411 Mile High Center, Denver, Colo.	Rotary, gas-gaso	600	8500
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	1600	15,000
	Rotary, diesel, gas-gaso	800	9000
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, gas-butane	750	7000
Sheridan County			
R. L. Manning Co.			
318 Continental Oil Bldg.,			
Denver, Colo.	Rotary, diesel	792	10,000
	Rotary, gas-butane	360	5000
Sublette County			
Clark Drlg. Co.			
Box 1743, Billings, Mont.	Rotary, diesel or gas-gaso	750	7500
Signal Drilling Co.			
203 Mayo Bldg , Tulsa, Okla.	Rotary, diesel, convertible	900	12,000
Sweetwater County			
Camay Drlg. Co.			
Box 391, Compton, Calif.	Rotary, gas-gaso	500	7000
Mountain States Drlg. Co., Inc.			
622 Patterson Bldg., Denver, Colo.	Rotary, diesel, gas-gaso	1200	10,000
Washakie County			
Cobb-Stringer Drlg.			
Box 118, Denver 1, Colo.	Rotary, gas-gaso	754	10,500
George Noland Drlg. Co., Inc.			
823 S. Detroit Ave., Tulsa, Okla.	Rotary, gas-butane	440	5000
Kerr-McGee Oil Industries Inc.			
Kerr-McGee Bldg.,			
Oklahoma City, Okla.	Rotary, gas-gaso	1680	15,000
Weston County			
Black Hills Drlg. Co., Inc.			
Newcastle, Wyo.	Rotary, diesel	1000	15,000
C. D. Lee Drlg. Co.			
Newcastle, Wyo.	Cable tool, ga-gaso	125	2000
Perl Smith Drlg. Co.			
Box 890, Newcastle, Wyo.	Cable tool, gas-gaso	145	10,000
Progressive Drlg. Co., Inc.			
New First State Bk. Bldg.,			
Newcastle, Wyo.	Cable tool, gas-gaso	175	3500
	Rotary, diesel	550	8000
Yoakum County			
Shirley Miller Drlg. Co.			
Box 1045, Midland, Texas	Rotary, diesel		7500
CANADA			
Alberta Province			
Cascade Drlg. Co., Ltd.			
510-A 8th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel		5700
	Rotary, diesel		9200
	Rotary, diesel		5500
	Rotary, diesel		7500
	Rotary, diesel		7500
	Rotary, diesel		8000
	Rotary, diesel		6500
	Rotary, diesel		6000
	Rotary, diesel		5000
General Petroleum of Canada, Ltd.			
224 9th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel		6000
	Rotary, diesel		6000
	Rotary, diesel		7000
	Rotary, diesel		10,000
	Rotary, diesel		6500
	Rotary, diesel		13,000
	Rotary, diesel		12,000
	Rotary, diesel		6500
	Rotary, diesel		7000

XUM

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
Commonwealth Drlg. Co., Ltd.			
122 8th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	530	6500
	Rotary, diesel	1500	14,000
	Rotary, diesel	420	6500
	Rotary, diesel	600	6500
	Rotary, diesel	600	8000
	Rotary, diesel	940	10,500
	Rotary, diesel	300	5500
	Rotary, diesel	450	6500
	Rotary, diesel	465	6500
	Rotary, diesel	530	7500
	Rotary, diesel	900	10,500
	Rotary, diesel	900	10,500
	Rotary, diesel	800	8500
	Rotary, diesel	1410	12,000
Gustavson Drlg. Co., Ltd.			
208 Alberta Block,			
Calgary, Alberta, Canada	Rotary, diesel	500	7500
	Rotary, diesel	300	6000
	Rotary, diesel	300	5500
Hunter Drlg., Ltd.			
602 7th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	600	6000
Palmer Oil Development Co., Ltd.			
New Royal Bk. Bldg.,			
Calgary, Alberta, Canada	Rotary, diesel	1645	10,000
Moore Drlg. Co., Ltd.			
6th Floor Petroleum Bldg.,			
Calgary, Alberta, Canada	Rotary, diesel	640	7000
	Rotary, diesel	1000	10,000
Pennant Drlg., Ltd.			
203 Mayo Bldg., Tulsa, Okla.	Rotary, diesel	500	7500
	Rotary, diesel	500	7500
	Rotary, diesel	550	8500
	Rotary, diesel	550	8500
Reading & Bates Drlg. Co., Ltd.			
Royal Bk. Bldg.,			
Calgary, Alberta, Canada	Rotary, gas-gaso	1400	14,000
	Rotary, gas-gaso	1100	12,000
	Rotary, gas-gaso	800	8000
	Rotary, gas-gaso	700	7000
	Rotary, gas-gaso	750	8000
	Rotary, gas-gaso	650	7000
	Rotary, gas-gaso	1100	14,000
	Rotary, diesel	520	6000
	Rotary, diesel	520	6000
	Rotary, diesel	520	6000
	Rotary, diesel	520	8000
	Rotary, diesel	780	10,000
	Rotary, diesel	520	8000
	Rotary, diesel	780	10,000
	Rotary, diesel	520	6000
	Rotary, diesel	780	12,000
	Rotary, diesel	520	6000
	Rotary, diesel	520	8000
Trinity Canadian Drlg. Co.			
237 7th Ave. N.,			
Calgary, Alberta, Canada	Rotary, diesel	670	10,000
British Columbia Province			
Commonwealth Drlg. Co., Ltd.			
122 8th Ave. West,			
Calgary, Alberta Canada	Rotary, diesel	600	8000
	Rotary, diesel	530	6500
Regent Drlg. Co., Ltd.			
Box 421, Edmonton, Alberta, Canada	Rotary, diesel	780	10,000
Trinity Canadian Drlg. Co.			
237 7th Ave. N.,			
Calgary, Alberta, Canada	Rotary, diesel	990	12,000
	Rotary, diesel	990	12,000
	Rotary, diesel	400	7000
Manitoba Province			
Cascade Drlg. Co., Ltd.			
510-A 8th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	.....	4500
	Rotary, diesel	.....	3800
Commonwealth Drlg. Co., Ltd.			
122 8th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	170	4500
	Rotary, diesel	170	4500
Moore Drlg. Co., Ltd.			
6th Floor Petroleum Bldg.,			
Calgary, Alberta, Canada	Rotary, diesel	190	4500
Palmer Oil Development Co., Ltd.			
New Royal Bk. Bldg.,			
Calgary, Alberta, Canada	Rotary, diesel	520	5500
Regent Drlg. Co., Ltd.			
Box 421, Edmonton, Alberta, Canada	Rotary, diesel	520	5500
	Rotary, diesel	520	5500
	Rotary, diesel	520	6000
	Rotary, diesel	520	5500
Northwest Territories Province			
General Petroleums of Canada, Ltd.			
224 9th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	.....	2500
Ontario Province			
Fen-Par Exploration Co.			
Box 282, Grand Haven, Mich.	Rotary, diesel	80	2400
Saskatchewan Province			
Commonwealth Drlg. Co., Ltd.			
122 8th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	310	5000
	Rotary, diesel	600	7000
	Rotary, diesel	480	6500
	Rotary, diesel	300	5500
	Rotary, diesel	450	6500
	Rotary, diesel	300	5500
	Rotary, diesel	300	5000
	Rotary, diesel	300	5000
General Petroleums of Canada, Ltd.			
224 9th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	.....	4200
	Rotary, diesel	.....	5000
	Rotary, diesel	.....	5500
	Rotary, diesel	.....	4200
Gold Star Drlg. Co., Ltd.			
1855 Scarth			
Regina, Saskatchewan, Canada	Rotary, diesel	140	3000
	Rotary, diesel	75	2200
	Rotary, diesel	159	5000
	Rotary, diesel	400	6500
	Rotary, diesel	104	4800
	Rotary, diesel	159	5000
	Rotary, diesel	175	3000
	Rotary, diesel	80	2000
	Rotary, diesel	340	4500
	Rotary, diesel	400	6000
	Rotary, diesel	225	4000
	Rotary, diesel	340	5000
Hunter Drlg., Ltd.			
602 7th Ave. West,			
Calgary, Alberta, Canada	Rotary, diesel	600	6000
	Rotary, diesel	600	6000
Palmer Oil Development Co., Ltd.			
New Royal Bk. Bldg.,			
Calgary, Alberta, Canada	Rotary, diesel	445	4000
	Rotary, diesel	353	3000
	Rotary, diesel	520	5500
	Rotary, diesel	975	7500
Regent Drlg. Co., Ltd.			
Box 421, Edmonton, Alberta, Canada	Rotary, diesel	520	8000
	Rotary, diesel	520	6000

Texas Now Has 'Davy Crockett' Oil Field

The 5000th oil field to be discovered in Texas has been assigned the name "Davy Crockett" in honor of the famous Texas hero of the Alamo. Railroad Commission Chairman William J. Murray, Jr., said the Commission had approved the field's name in accordance with the request of the discoverers, Charlie C. Winn and Glen A. Martin, of San Antonio. The name was derived in part from the fact that the discovery well produces from the Crockett sand, at a depth of 1377 ft. The new field is located in Zapata County, approximately 50 miles from Laredo.

SUPPLEMENT: (Additional Rig Locations received late in printing schedule)

Contractor's Name, Address	Type Rig and Prime Mover	Approx. HP Drawworks	Drilling Depth Ft
ARKANSAS			
Calhoun County			
Kern-Trimble Drlg. Co.			
McAlester Bldg., Magnolia, Ark.	Rotary, diesel	250	6500
Miller County			
Kern-Trimble Drlg. Co.			
McAlester Bldg., Magnolia, Ark.	Rotary, diesel	250	6500
	Rotary, butane	250	8000
CALIFORNIA			
Fresno County			
Clyde Hall Drlg. Co., Inc.			
2543 S. Union Ave., Bakersfield, Calif.	Rotary, gas-gaso	900	12,000
Los Angeles County			
Clyde Hall Drlg. Co., Inc.			
2543 S. Union Ave., Bakersfield, Calif.	Rotary, diesel	600	9000
Santa Barbara County			
Clyde Hall Drlg. Co., Inc.			
2543 S. Union Ave., Bakersfield, Calif.	Rotary, diesel	300	5000
Wahkiakum County			
Clyde Hall Drlg. Co., Inc.			
2543 S. Union Ave., Bakersfield, Calif.	Rotary, diesel	600	9000
ILLINOIS			
Hamilton County			
T. M. Pruett			
P. O. Box 303, Centralia, Ill.	Rotary, diesel	300	6000
Wayne County			
T. M. Pruett			
P. O. Box 303, Centralia, Ill.	Rotary, diesel	300	8000
KANSAS			
Barber County			
Graham-Messman-Rinehart Drlg. Co.			
P. O. Box 1033, Wichita, Kan.	Cable tool, diesel	160	.....
	Cable tool	190	.....
Comanche County			
Graham-Messman-Rinehart Drlg. Co.			
P. O. Box 1033, Wichita, Kan.	Rotary, diesel	550	6000
Ellis County			
Graham-Messman-Rinehart Drlg. Co.			
P. O. Box 1033, Wichita, Kan.	Rotary, diesel	180	4000
Graham County			
Graham-Messman-Rinehart Drlg. Co.			
P. O. Box 1033, Wichita, Kan.	Rotary, diesel	380	4500
Kiowa County			
Graham-Messman-Rinehart Drlg. Co.			
P. O. Box 1033, Wichita, Kan.	Rotary, diesel	550	6000
LOUISIANA			
East Cameron Area (offshore)			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	1350	16,000
Eugene Island Area (offshore)			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	1000	14,000
Grand Isle Area (offshore)			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	125	15,000
St. Martin Parish			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	10,500	10,500
	Rotary, diesel	75	10,500
West Delta Area (offshore)			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	1600	15,000
Vermilion Parish			
Columbia Drlg. Co.			
1208 C & I Life Bldg., Houston, Texas	Rotary, gas-gaso	450	8000
NEW MEXICO			
Eddy County			
Carper Drlg. Co., Inc.			
Carper Bldg., Artesia, N. M.	Cable tool	125	3500
Lea County			
Carper Drlg. Co., Inc.			
Carper Bldg., Artesia, N. M.	Rotary	560	7500
	Cable tool	145	5000
OKLAHOMA			
Alfalfa County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	225	5500
Carter County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	225	5500
Creek County			
Sams Drlg. Co.			
623 N. Main, Tulsa, Okla.	Rotary, gas-gaso	175	3000
Garvin County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	650	8800
	Rotary, gas-gaso	650	9500
	Rotary, gas-gaso	975	14,000
	Rotary, gas-gaso	975	13,500
	Rotary, gas-gaso	650	10,500
	Rotary, gas-gaso	650	10,500
Grady County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	975	15,000
	Rotary, gas-gaso	1530	18,000
Grant County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	450	5800
Lincoln County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	175	5000
Oklahoma County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	500	8500
Pawnee County			
Sams Drlg. Co.			
623 N. Main, Tulsa, Okla.	Rotary, gas-gaso	145	3500
Pottawatomie County			
Viersen & Cochran			
P. O. Box 280, Okmulgee, Okla.	Rotary, gas-gaso	225	5500
TEXAS			
Andrews County			
Hissom Drlg. Co.			
1115 Petroleum Life Bldg., Midland, Texas	Rotary, gas	600	8500
	Rotary, gas	450	6000
Brazoria County			
Bilbo-Redding Drlg. Co., Inc.			
1819 Semmes, P. O. Box 203, Houston, Tex.	Rotary, steam	.....	12,500
Chambers County			
Bilbo-Redding Drlg. Co., Inc.			
1819 Semmes, P. O. Box 203, Houston, Tex.	Rotary, diesel, barge	500	7500
Crane County			
Johnn Drlg. Co.			
711 Fair Bldg., Fort Worth, Texas	Rotary, gas-butane	350	5500
Ector County			
Johnn Drlg. Co.			
711 Fair Bldg., Fort Worth, Texas	Rotary, gas-butane	570	7500
	Rotary, gas-butane	990	10,000
Grayson County			
Johnn Drlg. Co.			
711 Fair Bldg., Fort Worth, Texas	Rotary, gas-butane	675	7500
	Rotary, gas-butane	1605	14,000
	Rotary, gas-butane	950	10,000
Guadalupe County			
Lewis and Mitchell			
115 W. Mountain, Seguin, Texas	Rotary, gas-gaso	140	2000
Texas Drillers, Inc.			
Box 47, Seguin, Texas	Rotary, gas-gaso	190	2500
Hardin County			
Bilbo-Redding Drlg. Co., Inc.			
1819 Semmes, P. O. Box 203, Houston, Tex.	Rotary, gas-gaso	645	8500
	Rotary, gas-gaso	950	12,000
Harris County			
Columbia Drlg. Co.			
1208 C & I Life Bldg., Houston, Texas	Rotary, gas-gaso	675	9000
W. L. B. Drlg. Co.			
6635 Chocolate Bayou Road, Houston, Texas	Rotary, gas-gaso	165	5000
Jackson County			
Columbia Drlg. Co.			
1208 C & I Life Bldg., Houston, Texas	Rotary, gas-gaso	850	10,500
Jim Wells County			
Hunt Drlg. Co., Inc.			
633 Wilson Bldg., Corpus Christi, Texas	Rotary, gas-gaso	350	6000
Liberty County			
Bilbo-Redding Drlg. Co., Inc.			
1819 Semmes, P. O. Box 203, Houston, Tex.	Rotary, gas-gaso	570	10,000
Jack W. Frazier			
339 Mellie Esperson Bldg., Houston, Texas	Rotary, diesel	.....	9000
Matagorda County			
Bilbo-Redding Drlg. Co., Inc.			
1819 Semmes, P. O. Box 203, Houston, Tex.	Rotary, diesel, barge	1005	12,000
Mitchell County			
Hissom Drlg. Co.			
1115 Petroleum Life Bldg., Midland, Texas	Rotary, gas	500	6000
	Rotary, gas	350	5000
	Cable tool, gas	150	.....
Nueces County			
Hunt Drlg. Co., Inc.			
633 Wilson Bldg., Corpus Christi, Texas	Rotary, gas-gaso	650	9000
	Rotary, gas-gaso	550	8000
Nueces County (offshore)			
Kerr-McGee Oil Industries, Inc.			
1110 Sterling Bldg., Houston, Texas	Rotary, diesel	100	14,000
San Patricio County			
Hunt Drlg. Co., Inc.			
633 Wilson Bldg., Corpus Chrisi, Texas	Rotary, steam	.....	10,500
WYOMING			
Big Horn County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, electric	200	6500
Carbon County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	1125	11,000
Fremont County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	1305	14,000
	Rotary, gas	360	6000
Hot Springs County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	750	7000
	Rotary, diesel	550	7000
Morgan County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	450	6500
Musselshell County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	450	6500
Natrona County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, diesel	550	7000
Park County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	750	7000
Reagan County			
Carper Drlg. Co., Inc.			
Carper Bldg., Artesia, N. M.	Rotary	675	9000
Runnels County			
Johnn Drlg. Co.			
711 Fair Bldg., Fort Worth, Texas	Rotary, gas-butane	675	7500
Sheridan County			
R. L. Manning Co.			
318 Continental Oil Bldg., Denver, Colo.	Rotary, gas	360	5000
	Rotary, diesel	825	10,000

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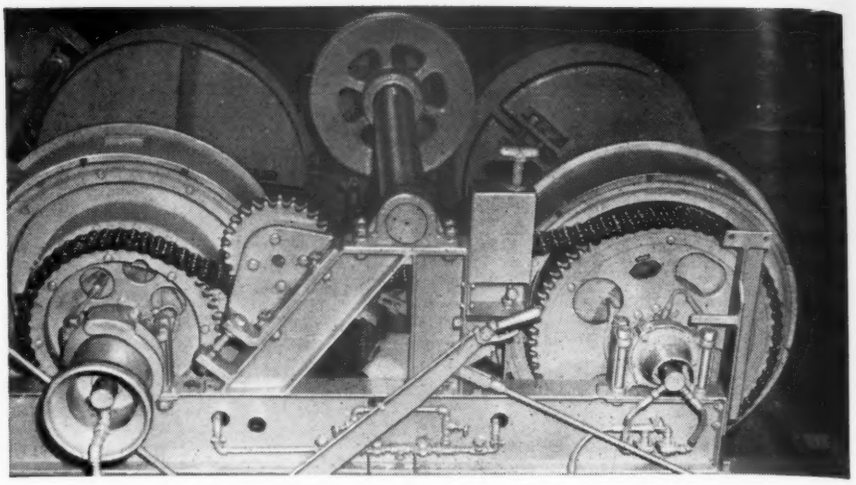
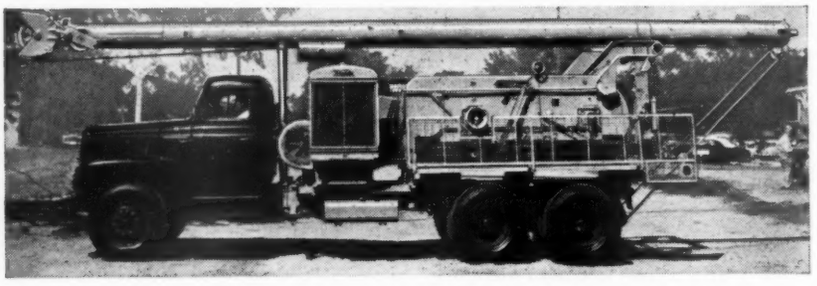


the drives are DIAMOND ROLLER CHAINS



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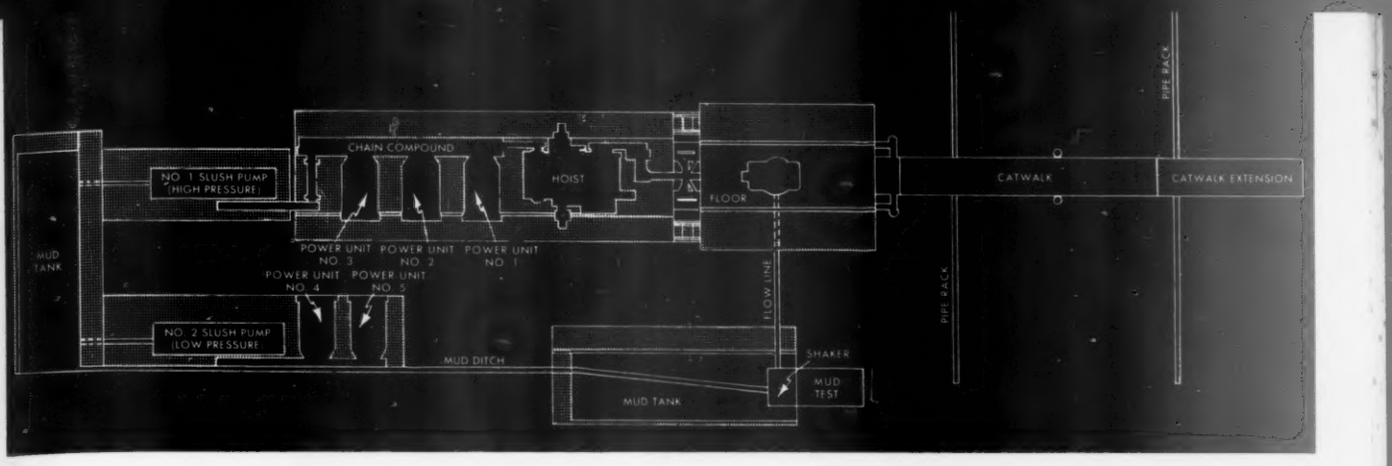

DRILLING FEATURE

Design of a SLIM HOLE rig

P 420.43

Factors point out importance of compactness and mobility

J. R. Hilder

THE oil industry scene has recently been enlivened by discussions of slim hole rotary drilling. Questions such as "How deep?" "What hole size?" and "What drill stem size?" have been raised by the industry. Intense engineering research and field experimentation have answered many of the questions regarding methods and procedure and will soon uncover the remaining unknowns. The individuals and firms involved in the laboratory and field work have reported their findings at petroleum meetings and in the trade journals; hence, the industry is well informed.

The discussions, research, and experimentation have been chiefly concerned with drilling methods and problems. Yet, the primary advantage of slim hole work has proved to be economic. No other advantage has developed, nor is expected.

The objective of the small bore operation is, then, a reduction in the cost per foot of hole drilled. It is gained by lower investment—smaller equipment and crews, reduced fuel needs, and reduced maintenance and transportation costs. A heavy conventional rig boring a small hole would not provide these cost reductions. "Smaller horsepower requirements" and "ease of transportation" sum up every list of slim hole advantages.

In order to obtain the maximum gains from small bore drilling, equipment must be designed and manufactured for the work. The first problem in assembling a slim hole rig, as in selecting a "conventional rig," is establishing the power requirements for circulating, hoisting, and rotating. With power requirements known, the rig components may be designed and arranged to meet the set of conditions peculiar to the slim hole operation—mobility and rapid rig up.

Hydraulic Requirements

The circulation of mud is a major job on any rotary rig and is the first consideration when establishing power requirements. Factors involved in hydraulic calculations are numerous, but the prime factor is volume of mud necessary to produce the desired veloci-

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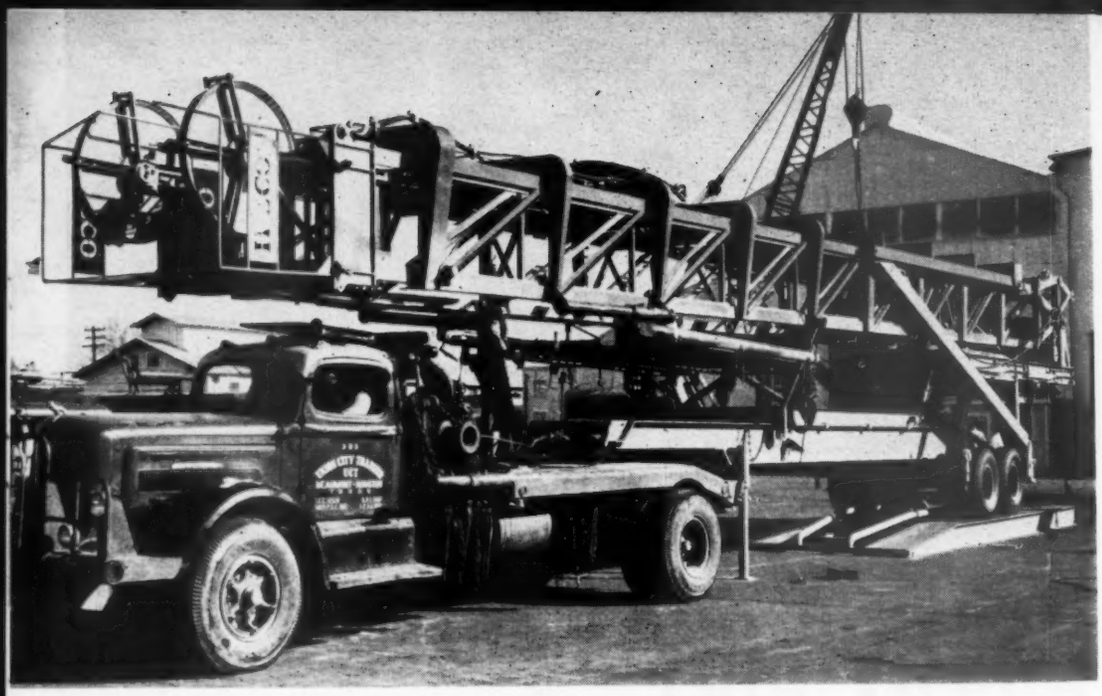
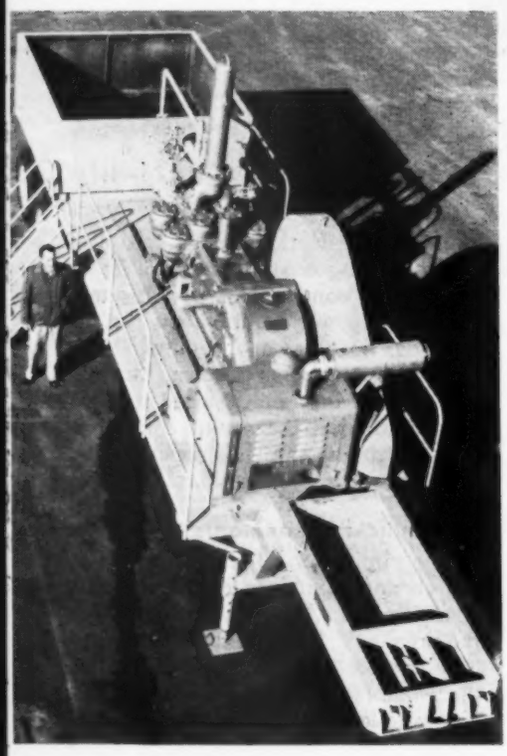


Portable mast in road position. Mast remains strung during moves to provide minimum rig up time.



Pumps are trailer mounted as are the other rig components. Unit shown is complete with pump, engine, and mud tank.

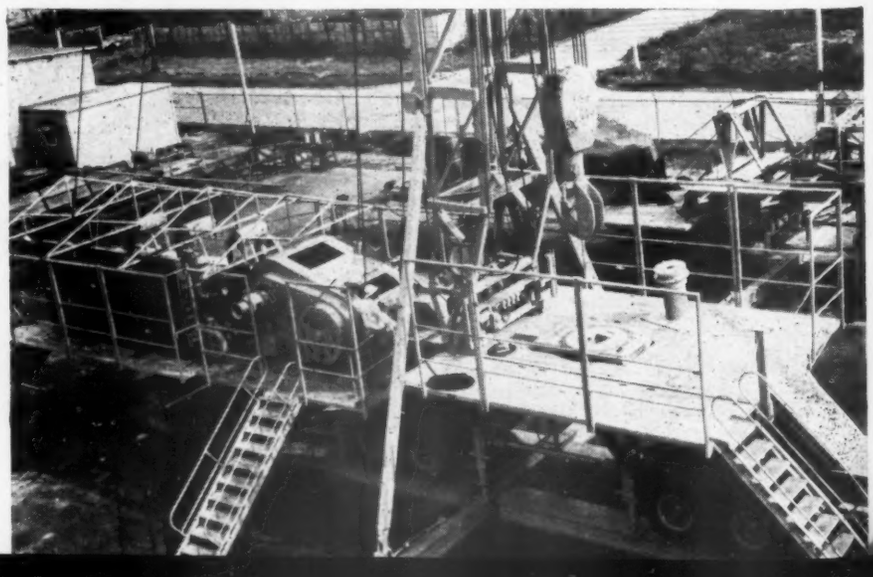
ties. The gallons per minute required determine the friction losses, which in turn determine the power required. Adequate annular velocities range between two and four feet per second in most operations. The higher velocity is often used in soft formations to carry more and larger cuttings. The volume of fluid required, however, should be less in slim holes due to the smaller annular clearances.

In Table 1, an annulus velocity of three feet per second is assumed. Other assumptions are 10-lb mud, 2-in. ID surface equipment and drill collars, and an 85 per cent mechanical efficiency of the pump. Since the use of jet bits should improve performance in a slim hole (in the same manner as they have in larger bore holes), bit nozzles were selected to provide a nominal jet velocity of 200 to 250 ft per second, in the calculation of pump horsepower.

The figures developed in Table 1 indicate slim hole operations are confronted with a high-pressure, low-volume hydraulic system. Using 2⅞-in. IF EU tubing, a 1275 psi system is required in a 4¾-in. hole at 12,500 ft. An increase in the hole size increases the pressure necessary to obtain the above annular return to 4090 psi in a 6¾-in. hole. With 3½-in. IF drill pipe, the pressures are not as critical but remain high in relation to volume. Two thousand psi will handle a depth of 12,500 ft in a 6¾-in. hole.

There are advantages in using 3½-in. drill pipe. Tool joints are available, and slips and tongs are standard. Of course, there is no possibility of drilling a 4¾-in. hole with 3½-in. drill pipe, due to physical limitations. A 5⅝-in. rock bit is the smallest that has standard bearings — bearing trouble with the smaller size bit is common. Core barrels, logging tools, fishing tools, drill stem testing, and perforating equipment are readily available in the 5⅝-in. or larger sizes. Like devices for smaller bores are often difficult to obtain.

Horsepower requirements are not excessive with either drill string due to low volume, but the pressures are such that the standard small pump will be overloaded at the gear end. The selection of the drill string should be coupled with careful procurement of the swivel, hose, standpipe, and other



Shown is the floor area and the rig up ready for drilling. The drawworks and mast-structure trailers are pinned together to form one unit.

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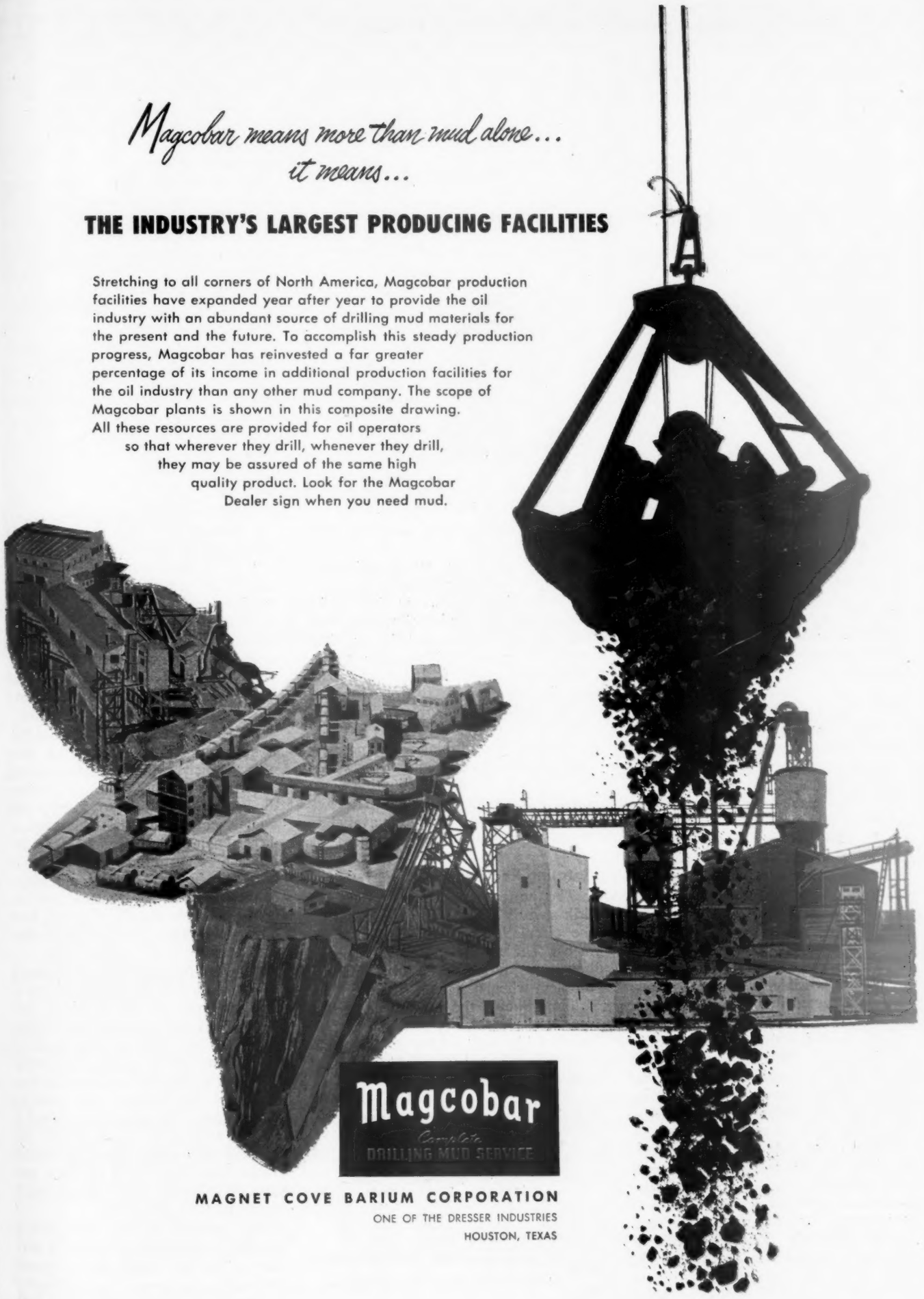

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TABLE 1. Approximate horsepower requirements for mud circulation.

Drill Stem	Bore Size	Gal Per Min.	5000 ft PSI	5000 ft HP	7500 ft PSI	7500 ft HP	10,000 ft PSI	10,000 ft HP	12,500 ft PSI	12,500 ft HP
2⅞ in.	4¾ in.	100	590	40	780	55	1010	70	1275	90
Internal Flush	5⅝ in.	170	830	95	1180	135	1530	180	1930	225
2⅛ in. ID 6.5#	6⅛ in.	210	1190	170	1650	240	2125	305	2650	380
E.U. Tubing	6¼ in.	220	1405	210	1780	270	2300	350	2850	43
	6¾ in.	270	1850	340	2575	475	3310	610	4090	755
3½ in.	4¾ in.	—	—	—	—	—	—	—	—	—
Internal Flush	5⅝ in.	140	465	45	650	60	875	85	1060	100
2¹¹⁄₁₆ in. ID	6⅛ in.	190	680	90	930	120	1210	160	1450	190
13.30# Drlg.	6¼ in.	200	740	100	900	135	1280	175	1545	210
Pipe.	6¾ in.	250	990	170	1335	130	1725	295	2070	355

top-hole equipment to eliminate constrictions that increase pressure.

A 5½-in. by 12-in. mud pump will deliver 250 gal of fluid per minute at 60 spm. From Table 1, it is apparent that this 250 gpm will provide the assumed annulus velocity in a 6¾-in. hole with a 3½-in. IF drill string. A pump of this size, however, would reach its pressure capacity at 6000-ft depth (approximately). Compounding two of the small pumps in series will provide the necessary pressure to reach the 12,500-ft depth. Where a torque-converter drive is employed, series operation of pumps is very successful. In fact, a smoother discharge characteristic and a more efficient utilization of hydraulic horsepower were observed in recent tests. It follows, then, that since the pressure peaks are materially reduced, the stresses imposed on the gear end of the pump are reduced accordingly.

Hoisting Requirements

The second consideration in adequately powering a slim hole rig is the hoisting requirements. Time is the important factor in any hoisting operation. It is especially true in small bore work because numerous round trips are made. Field records show that up to 30 per cent more bits have been used in a small bore to a given depth than were used in a "conventional" bore to the same depth. Hence, trip time was greater percentage-wise. The drawworks should be designed to get the drill string out of and into the hole as quickly as possible.

The accepted industry standard for adequate drawworks power is that necessary to start hoisting the drill pipe off bottom at 100 ft per minute at rated depth. Investigations show that while the horsepower required by these standards is desired, it is seldom obtained. A great many rigs are assembled to provide 100 hp per 1000 ft of 4½-in. drill pipe, which in most cases does not install sufficient horsepower to come off bottom at 100 ft per minute. For the reasons outlined above, slim-hole hoisting equipment should be powered to obtain the 100 fpm off-bottom performance. No "rule of thumb" should be employed when hoisting speeds are critical and affect drilling costs to any degree.

Table 2 illustrates the drawworks horsepower required in slim hole work with 2⅞-in. tubing and 3½-in. drill pipe at depths of 5000 ft, 7500 ft, 10,000 ft, and 12,500 ft. It is very apparent that the 3½-in. string requires a great many more "horses" than does the 2⅞-in. string.

As the 2⅞-in. tubing would necessitate a smaller investment in drawworks horsepower, the first inclination is to favor it over the drill pipe. The hydraulic picture above and the availability of tools must be considered.

The Author

J. R. Hilder is manager of prices and specifications for Ideco, one of the Dresser Industries. He joined the engineering department at Ideco's Beaumont, Texas, plant after receiving his BA and BS degrees from the University of Texas in 1948.

Rotating Requirements

The power required to rotate the drill stem is minor when compared to the circulating and hoisting requirements. The use of light-weight strings, however, presents a special rotating problem when designing for slim hole drilling. Should the full power of the drawworks engines be available to the rotary table, light tubing or drill pipe could easily be twisted off. Usually, the conventional power arrangement allows the full power to the hoist to be applied to the table. In slim hole work, the horsepower must be limited, and an interlock of controls should be devised to limit input to the rotary.

Another consideration in rotating power requirements is the relation of weight on the bit to revolutions per minute. Generally, the drill stem is kept in tension along with approximately one-quarter to one-third of the weight of the drill collars. In small bores, the lesser weight on the bit is offset by faster rotating speeds. Horsepower required for rotating in large bore work is usually estimated to be one horsepower per revolution. Comparing the strength of the drill stems used in slim holes with those used in large holes, the weights applied to the bits in each situation, and the rotating speeds of the two operations, it would seem that one-half the conventional rotating power is needed in slim hole work.

TABLE 2. Approximate power unit horsepower requirements for hoisting at rate of 100 fpm.

Depth Feet	Power Unit to Hook Efficiency	Drill Collar Weight	Drill Stem 2⅞in.(1)	Drill Stem 3½in.(2)
5,000 ft	65%	9,400 lb	165	295
7,500 ft	65%	11,100 lb	235	345
10,000 ft	65%	12,250 lb	300	570
12,000 ft	65%	12,250 lb	360	745

Note: (1) 2⅞ in. Internal Flush 2½ in. ID 6.5# E.U tubing.
(2) 3½ in. Internal Flush 2¹¹⁄₁₆ in. ID 13.30# drill pipe.

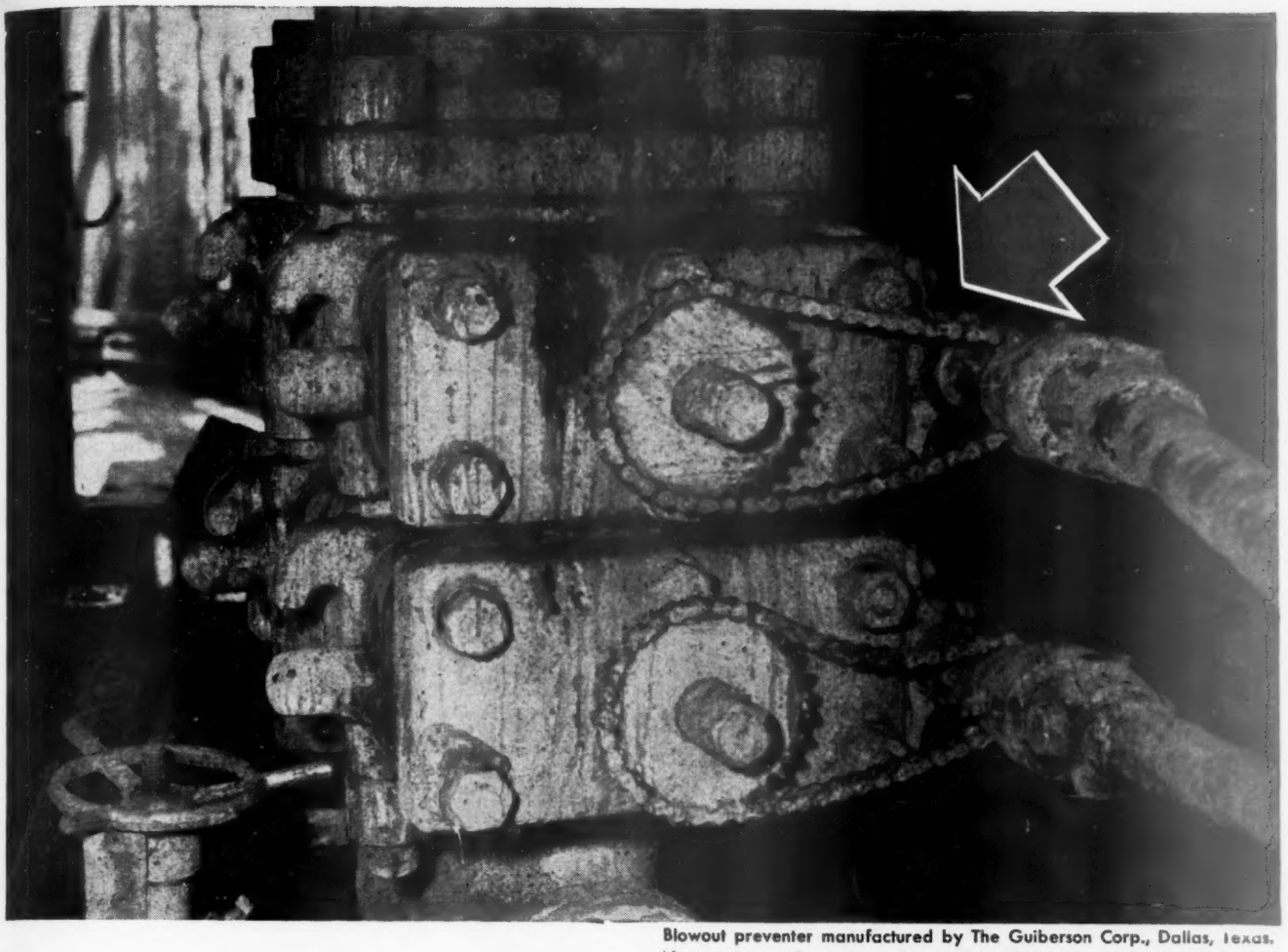
Rig Up

With major power requirements established, it is possible to consider the complete set up. A schematic layout of a hypothetical slim hole rig assembled to drill 10,000 ft (6¾-in. or smaller bore) is illustrated in Fig. 1. Drawworks, drilling mast, rotary substructure, pumps, and other components are trailer-mounted. The emphasis is on mobility and rapid rig-up and tear-down. Yet, performance and flexibility are not sacrificed.

The hoist selected is rated at 40,000-lb line pull at the main drum. With normal efficiency and eight lines strung, hook loads to 250,000 lb may be handled. A total of 500 to 550 hp adequately powers the hoist. Three gas or diesel engines developing 160 to 190 hp each (intermittent) are supplied to power the hoist. The addition of torque converters between the engines and hoist permits higher average hook horsepower and protects rig elements from shock.

A lever lift, portable drilling mast is recommended for the slim hole rig. In this case, the mast is rated at 250,000-lb hook-load capacity with a safety factor of two. The overall height of the mast is 105 ft and the "working" height 97 ft from the substructure floor to under the crown. This working height allows the pipe to be racked in doubles and, more important, has sufficient head room to allow mousehole connections. The faster trip time possible with a trebles mast will not justify the sacrifice of portability.

The portable mast in road position remains strung during moves. A storage reel for the drilling line is located under the pipe ramp. The mast trailer is actually a rotary substructure with



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an 8-ft floor height and with 200,000-lb pipe set back and rotary beam capacities. There is ample area under the substructure floor for blowout preventer equipment.

The 14½-in. rotary table is carried on the mast-substructure trailer in its normal operating position. The table drive is through a torque tube. No chains are broken when the rig is roaded since the torque tube drive is disconnected at the flange. Alignment between the hoist and rotary is assured, as the torque tube allows a degree of misalignment without impairing efficient operation. One hoist engine powers the table, and an air interlock prevents more than one engine driving into the table at any given time.

A large floor area, 16 ft by 18½ ft is provided by adding a 4-ft extension on each side of the 8-ft wide trailer deck. Handrails, extended for canvas windbreaks if desired, are included as are stairs to ground level and to the drawworks trailer. A frame for the engine house can be furnished on the drawworks package. Mast's crossover crown presents the "flat" side of the traveling block to the derrickman and also loads the mast evenly. A rathole digger is placed on the floor to ease that time-consuming job. It is chain driven from the rotary.

To obtain a desirable annular velocity of 3 fps (for 10,000 ft 6¾ in. drilling with 3½-in. drill pipe) requires less than 300 pump horsepower. Two 5½-in. by 12-in. Duplex pumps are selected to insure ample pressure and velocity in the mud system in the event circulation pressure losses are increased for any reason. The use of two identical pumps also allows the use of two of the drawworks engines on the No. 1 pump and two of the same engines on an independent pump drive. Operating costs and supplies are then kept to a minimum.

Torque converters are employed in the hoist and pump drives to increase the flexibility of operation and maintain ideal engine loading. A chain pump drive is utilized to obtain a lower moment of inertia than possible with a V-belt drive system. The result is a full opportunity for the torque converter to perform its function. The flywheel effect of a V-belt drive would minimize much of the "speed variation potential" inherent in the converter.

The pumps are trailer-mounted as are the other rig components. Suction and discharge manifolding are built into the trailers. Line pipe for use between the pumps, standpipe, etc., is carried on the vehicles during moves. The mud tanks are skid-mounted, and pump suction is flooded by slush pump charging pumps. One tank handles active mud requirements. A similar tank provides reserve mud. The shale shaker is permanently mounted on one of the tanks. When moving (empty), rig up items are transported in the tanks. Thus, the tanks become "carryalls."

A study of the features of the Slim Hole Rotary Rig sketched above indicate that a 100 per cent portable rig is possible. The investment in wheels will "pay out" in transportation, labor, and time savings when rigging up and tearing down.

The smaller horsepower requirements of slim hole work do not dictate heavy, expensive machinery. A 10,000-ft well drilled with a 500-hp drawworks and two 5½-in. by 12-in. slush pumps costs much less than a well drilled to that depth with a 1000-hp hoist and two 7¼-in. by 18-in. pumps. The small bore rig has reduced investment, trucking, labor, and fuel costs as much as 25 per cent. The future should see deeper service and even greater cost reduction.

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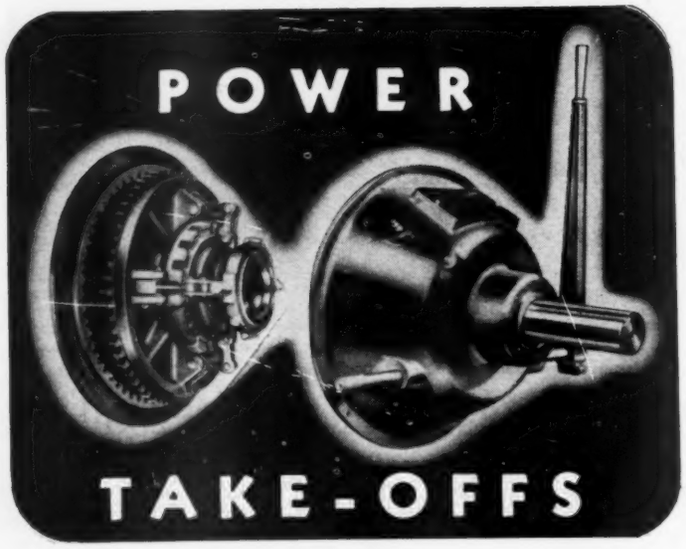

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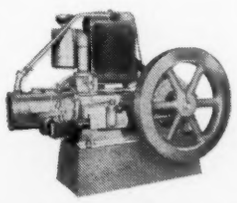

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DRILLING FEATURE

Economics of SLIM HOLE Drilling

Philip L. McLaughlin

Savings Indicated All Down the Line. Solution to More Slim Holes Lies Within Realm of Contractor-Producer Relationship.

FIG. 1. To provide the contractor an opportunity to realize attractive profits from slim hole drilling, the rig itself must be compact and permit fast rig up. The rig shown can be rigged up in about six hours.

EDITOR'S NOTE: This article is a condensation of the chapter on Economic Considerations taken from the book **Slim Hole Facts** prepared by the author and recently published by the Cardwell Manufacturing Company.

If slim holes are to become an important part of the total number of wells drilled each year, they must offer attractive profit opportunities to both the producer and contractor. While it has already been established that slim hole drilling and completion techniques offer producers important savings in many areas, it is not nearly so clear what the effect will be on the contractor's financial position. In order to properly evaluate slim hole drilling, it is necessary to consider:

- Where does the drilling contractor's money go.
- Economic considerations from the producer's viewpoint.
- Producer-contractor relationships.

Where Does the Drilling Contractor's Money Go?

Overhead and Profit. The more idle time a rig has, the less opportunity it has to take its share of the overhead load, and the more the contractor has to charge eventually if he is to stay in business. Any contractor who finds it necessary to take "no-profit" big hole contracts to keep his crew together might do well to investigate the savings made possible by slim hole drilling. In some areas, slim hole contractors with proper equipment are reporting that they can underbid big hole contractors 10 to 20 per cent and still take care of overhead and make good profits.

Moving Costs. In a recent survey, operators in several widely scattered sections of the country reported contract rates of $2.00 to $2.50 per foot for 4000 to 7000-ft wells in medium formations (Gulf Coast and Denver-Julesburg Basin). This means that 4000 to 7000-ft wells cost operators $8000 to $17,000 for drilling alone on footage contracts.

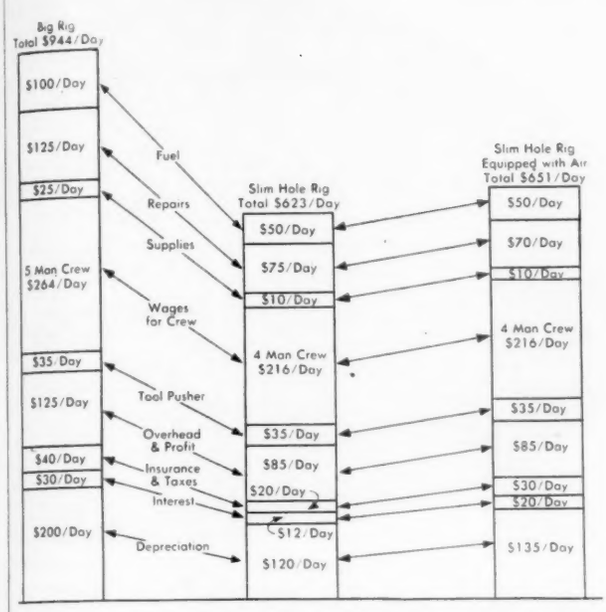

FIG. 2. *Contractors Daily Rig Costs.* These hypothetical figures are based on 1500-day straight line depreciation and 6 per cent interest on the average investment. The 10,000-ft big rig is rated from 900 to 1200 hp, while slim hole rigs fall in the 300 to 500-hp class. It is assumed that the rig equipped with air is a contractor-owned, rig-powered system.

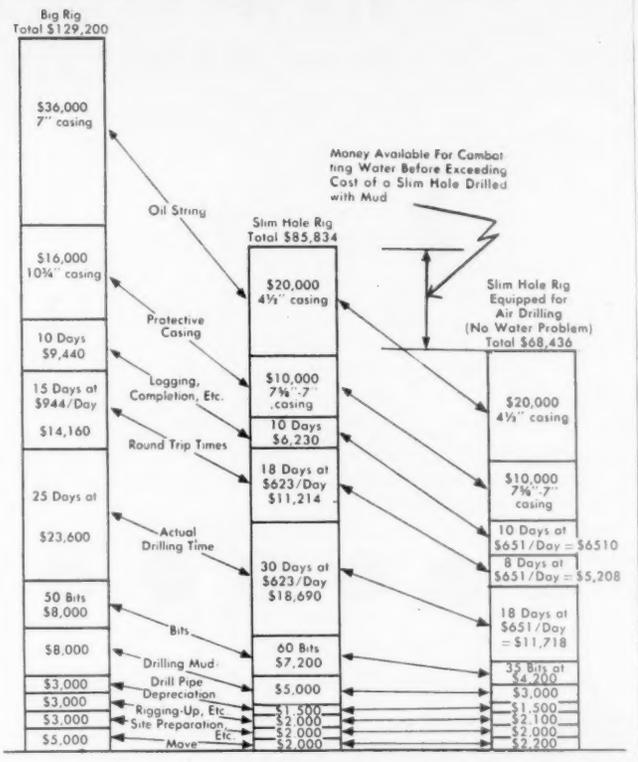

FIG. 3. *Comparative Total Well Costs* (except tubing and Christmas tree) for three 10,000-ft wells. These wells represent a composite of conditions found in many areas. While the costs may not match any single set of well costs, they resemble the costs in many areas. They are presented for purposes of comparison only and show economies with slim hole drilling.

Since moving a big rig may amount to $4000 to $5000 per well, it is easy to see that this can be an important part of the contract price. It is essential that successful contractors reduce these moving costs as much as possible. Important ways of cutting these costs are:

1. Reduce tonnage of iron to be moved.
2. Reduce the number of loads per rig.

Slim hole drilling offers an ideal way to reduce moving costs because for a given well depth, the slim hole rig will frequently weigh less than half the conventional rig. A modern trailer-mounted rig suitable for drilling and completing 10,000-ft slim holes will weigh no more than 275,000 lb including the drill string. It will require only 7 to 9 loads in most states. By contrast, a conventional 1000-hp rig suitable for 10,000-ft "big hole" drilling may weigh 800,000 lb and require more than 20 loads. The difference in moving costs alone can mean the difference between profit and loss.

Site Preparation. Smaller sites, mud pits (where used) and less elaborate roads and boardwalks cost less for the smaller rig. These costs, however, will not go down as fast as rig size.

Rigging-up Time. Frequently, it requires from 2 to 4 days to rig up a 1000-hp rig and may cost as much as $3000. A trailer-mounted rig can be rigged up in less than a day's time at a total cost of less than $1000. This saving alone could easily cover the office overhead for an entire well.

Drilling Mud. The volume of an 8¾-in. hole is approximately twice that of a 6⅛ in hole. Since mud volume requirements are roughly proportionate to hole volume, a substantial saving in mud costs can be expected.

Many operators will pay closer attention to their mud conditioning program when drilling smaller holes. This may increase the cost per barrel of mud used, but, since less mud is needed, lower mud costs can be anticipated. It is reasonable under many circumstances to expect saving of $3000 to $5000 or more on mud costs alone. In areas where exceptionally heavy muds are required and where mud bills of $25,000 to $125,000 are incurred, savings can be considerable if slim hole techniques could be employed.

Drill String Costs. A check with pipe suppliers chart shown in Table 1 indicates than 4½-in. drill pipe with tool joints will cost nearly twice as much as 2⅞-in., N-80 tubing with tool joints. In most areas, a tubing drill string should last almost as long as 4½-in. drill pipe provided appropriate care is given both strings. While this may not be completely true in certain areas where corrosion fatigue and abrasion are serious problems, a saving of at least ⅓ in drill string costs may be anticipated.

Some operators are trying to reduce further drill string costs by using couplings rather than tool joints. In the future, this practice may effect a con-

Table 1. Drill string prices and weights.

These approximate prices are for comparison only. They include the mill price of the pipe and the approximate price of 3⅓ screwed-on tool joints for each 100 ft of pipe. Transportation charges, hand-facing charges, and charges for installing tool joints are not included.

OD of pipe	Grade of pipe	Total drill string weight including tool joints, pounds per 100 ft	Total price per 100 ft
2⅜ in.	4.70 lb N-80 EUE tubing	520	$190.00
2⅞ in.	6.50 lb N-80 EUE tubing	740	226.00
3½ in.	9.30 lb N-80 EUE tubing	1100	283.00
3½ in.	13.30 lb grade D drill pipe	1500	320.00
4½ in.	16.60 lb grade D drill pipe	1940	397.00

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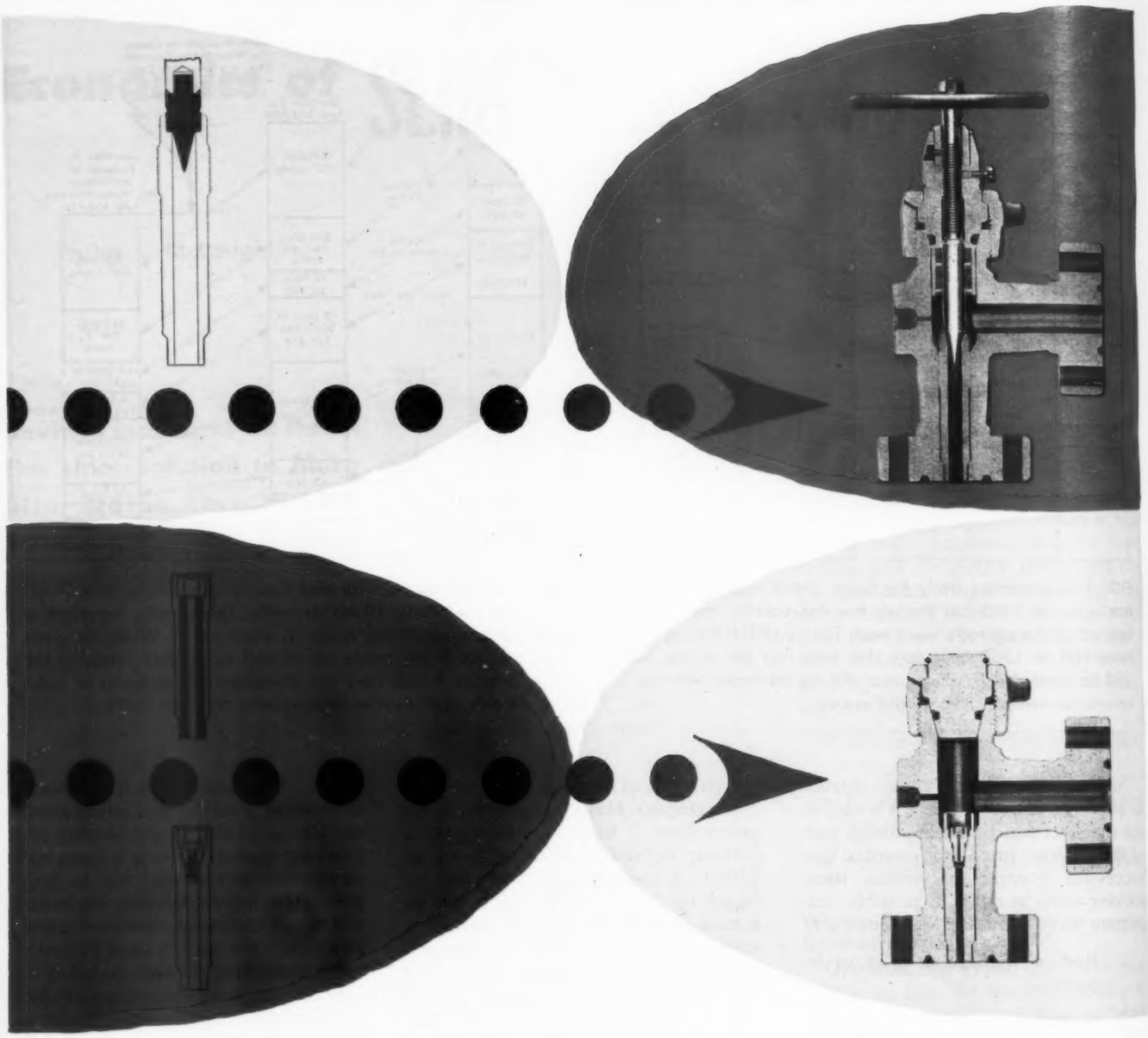

In scores of field tests, O•C•T chokes have proved superior to any other choke in wear-resistance

Now you can add greater wear-resistance to the other advantages . . . economy, speed, flexibility, strength and simplicity . . . that have made O-C-T Production Chokes the most popular in the field. Designed specifically to get the job done at extreme high pressures, these O-C-T Chokes will give you trouble-free, long life service under any field conditions you encounter. They're available through more than 700 supply store outlets . . . because more supply stores carry more O-C-T Chokes and choke parts than any other make.

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siderable further saving, especially if the drill string can be set as the casing string.

Drill Collar Costs. Important savings cannot be expected from the drill collar string for two reasons: (1) A given weight of 4½-in. drill collar (suitable for drilling 5⅝-in or 6⅛-in. hole) will cost nearly 50 per cent more than the same weight of 6½-in. drill collars. While lighter drilling weights are generally used with smaller bits, field reports so far received do not indicate that these weights are sufficiently lighter to reflect important savings in drill collar costs. (2) It is generally conceded that a slim hole contractor runs a slightly higher risk in fishing jobs and stands less chance of retrieving drill collars.

In view of these facts, it appears that a contractor should not anticipate any important reduction in drill collar costs when drilling slim holes. In case of trouble, cheaper holes make it conducive to skid over and drill a new hole.

Bits. As a general rule, roller bits in the popular slim hole sizes (5⅝, 6⅛ and 6¾ in.) will cost 20 to 30 per cent less than corresponding regular size bits (7⅞, 8¾, and 9⅝ in.).

Bit improvements in slim hole sizes appear to be giving almost as much footage per bit in some areas as corresponding bits in large sizes. Not even the most pessimistic observers will give large bits more than 30 per cent footage advantage. It appears safe to say that at worst, bit costs will be little more with slim holes than with regular holes. In all probability, they may run from 10 to 30 per cent lower.

With diamond bits, a different situation exists. The chief cost factor in diamond bits is the diamonds used. The cost of diamonds varies roughly as the square of the bit diameter. A 6⅛-in. diamond bit will cost nearly 40 per cent less than an 8¾-in. bit. Since diamond bit performance does not deteriorate in the smaller sizes, it may be practical in some hard formation areas to run 3¾ or 4¾-in. diamond bits and realize great savings in bit costs.

Crew Wages. Many slim hole rigs can be operated very easily with four-man crews. And, some can be operated satisfactorily with three men. A drilling contractor can take advantage of this saving in manpower in any one of several ways. He can, of course, take immediate advantage of the $35 to $60 savings daily per crew member by using smaller crews without changing hours or working conditions. Or, he can use the extra manpower thus made available to improve working conditions or provide additional days off for crew members.

Savings may not be so direct in this latter instance, but it is entirely possible that the contractor may realize even larger savings in the long run because he is able to attract and keep better men for a longer period of time. Some companies are using the three-man crew and offering extra pay to crew members for the added work load involved. Regardless of the course a drilling contractor takes, he can expect savings up to 20 per cent or more in labor costs.

The Author

Philip L. McLaughlin is head of the product and drilling research department of Cardwell Manufacturing Company, Inc., Wichita, Kansas. A graduate petroleum engineer of the University of Texas, he has served with the Ohio Oil Company and Continental Oil Company in several capacities. He is co-chairman of the Southwestern District API Study Committee on surface mud systems, and has been appointed to several posts on AIME, API and AAODC committees to study air drilling and slim hole drilling techniques. Prior to joining Cardwell in April, 1955, McLaughlin was drilling editor for *World Oil*.

Rig Repairs. A slim hole rig should require fewer repairs than a big rig, provided component parts are of equal quality. It is estimated by some authorities that savings in repair costs of ⅓ might be expected.

Fuel. Fuel consumption depends on such items as pump pressure and pump volumes under various conditions as well as hoisting power and rotary torque requirements. A review of conventional slim hole rigs rated for the same depths will reveal that compound slim hole rigs rarely need more than half as much peak power as big rigs. Even allowing for a somewhat higher load factor, important savings in fuel might be anticipated. One major oil company has estimated that these savings might average $25 per day when drilling 5000-ft slim holes. From a percentage standpoint, fuel savings of 25 to 60 per cent might be expected.

Round Trips. Most slim hole rigs now in use are limited by mast height to hoisting and racking doubles. While many factors influence round-trip speeds, it is safe to say that when other things are equal the rig that can rack "thribbles" will make faster round trips.

Other things are not equal, of course, when small rigs are compared with large, big-hole rigs. The lighter slim hole drill strings, plus the widespread use of power tongs, favor fast handling of pipe. Even so, slower round trips can be expected when mast height is limited to doubles.

The importance of fast round trips will depend to some extent upon the area in which drilling is conducted. Along the Gulf Coast and in the Denver-Julesburg Basin, for example, where two to five bits may make a 5000-ft hole, contractors may prefer the lighter weight and lower cost of a "doubles" mast.

In the Permian Basin of West Texas, on the other hand, where 35 or more bits may be used in drilling a single well, round-trip speeds can become most important, and a contractor may profitably employ a "thribble" mast.

Many recent developments such as diamond drilling bits, tungsten carbide roller bits, experimental percussion bits, and air drilling all combine to minimize the importance of fast round-trips and emphasize the need for light weight, highly portable rigs that require a minimum of rigging-up time.

Economics from the Producer's Viewpoint

Drilling contractors may benefit in many ways from the widespread adoption of slim hole drilling. Producers rather than drilling contractors, however, reap the principal benefits. Producers will eventually get most of the benefits from reduced rig costs and reduced overall drilling costs. While the slim hole drilling contractor can frequently realize good profits in competitive situations where the "big-rig" contractor cannot operate profitably, the net result has been, and will probably continue to be a reduction in drilling costs for the producer. The most important reductions are in the form of lower day rates and lower contract footage charges, but the operator can realize important additional savings in logging, casing, perforating, cementing, and completion costs.

Logging, Etc. In logging, perforating, and other services, the basic charge by the service company will probably remain unchanged. The 30 to 50 per cent reduction in rig day rates, however, will reduce overall costs significantly.

Cementing Costs. Frequently, there will be a reduction in the amount of cement used, but this reduction will be small in comparison with the total cement charges. Here again, the chief saving will be a reduction in rig day rates.

Casing Costs. The biggest single saving in completion costs will be the reduction in casing costs. A quick reference to Table 2 will show that pipe costs decrease quite rapidly with pipe size. The greatest saving could be ex-

Table 2. Relative costs and weights of tubular goods.

The following approximate carload mill prices per 100 ft are for purposes of comparison only. The pipe supplier should be consulted for accurate prices, including transportation charges, etc.

API Seamless Steel Casing
Grade N-80, Long Threads and Couplings

OD of pipe	Weight per ft	Price per 100 ft
4½ in.	11.60 lb	$123.00
5 in.	15.00 lb	152.00
5½ in.	20.00 lb	206.00
6 in.	20.00 lb	214.00
6⅝ in.	28.00 lb	292.00
7 in.	32.00 lb	320.00

API Seamless Tubing
External Upset, Grade N-80

OD of pipe	Weight per ft	Price per 100 ft
2⅜ in.	4.70 lb	$ 64.00
2½ in.	6.50 lb	87.00
3½ in.	9.30 lb	121.00
4 in.	11.00 lb	142.00
4½ in.	12.75 lb	160.00

pected in those cases where 2⅞ or 3½-in. tubing could be used as an oil string. But, important savings can be expected with 4-in. tubing or 4½ to 5-in. casing. A relatively complete line of permanent-type completion equipment is available in the latter sizes.

Casing Crew Charges. These costs will probably remain unchanged. Here again, the chief saving will be the rig day rates unless the pipe used for casing is a size than can be effectively handled by the rig crew or a tubing crew. When this is the case, an important saving in casing crew charges might be expected. In the event of a dry hole where an oil string is not set, the saving in casing costs will be confined to the surface and protective strings.

Field Development Wells. Traditionally, slim holes are considered most suitable for exploration and wildcat wells. When oil is found, many operators prefer large casing programs for development wells. This idea has considerable merit in the case of flush production and for wells in areas where high allowables are permitted. One major producer, however, has estimated that the vast majority of wells in the U. S. have allowables that can be produced easily through slim hole completions. Furthermore, slim hole completion techniques can reduce both completion and workover costs, especially if permanent-type completions are used. Because of these considerations, many of the leading producers are looking to slim holes for field development as well as for exploration.

Multiple Casing Strings. In certain areas, notably along the Gulf Coast, it is necessary to set several strings of casing (to shut off fresh water, heaving formations, upper producing zones, salt water flows, etc.). In these cases, it may not be practical to use slim hole equipment, but it might be practical to take advantage of smaller casing costs that result from a small-diameter casing program.

Other Savings. Some savings may be expected through the use of smaller tubing, sucker rods, Christmas trees, and surface equipment. Preliminary indications are that these savings will not be important when viewed over the producing life of the well.

Producer-Contractor Relationships

If the savings outlined in the foregoing are likely, contractors and operators might ask, "If slim hole drilling is so good, why isn't it used more?" The most immediate answer is industry inertia, but that alone would fail to explain the relatively slow progress in acceptance of slim hole drilling. More important reasons are to be found in the risk/profit ratio and the producer-contractor relationships.

What's Retarding Slim Hole Drilling? It is generally conceded that there is a slightly greater danger of trouble when drilling slim holes. The small drill strings can't stand the torque of larger sized strings, and twistoffs are more likely to occur. Small bits can't stand excessive weights as well as large bits, so, there is more danger of lost cones and worn out bearings.

More crooked hole problems can be expected because of the smaller drill collars and their greater relatively flexibility. There is a greater possibility of fishing jobs, and there is somewhat less chance of recovering drill collars in the event of a fishing job. As every contractor knows, the cost of lost collars can eat up profits rapidly.

Heaving formations and caving holes can cause trouble more easily in the case of slim holes, and many contractors believe it is necessary to maintain closer control of drilling mud characteristics in order to achieve reasonable safety.

While recent slim hole drilling experience does not indicate that any of these problems are particularly severe, most authorities agree that the problems grouped together result in greater risk as well as in lower drilling costs.

Unanswered Questions. The prime unanswered question at present is "who will take these added risks and who will profit from lower costs?" If the drilling contractor goes on "day work" and lets the operator take full risk for lost drill strings and other hazards, he is obviously freed of the risk element. He is also deprived of most opportunities to realize good profit. As a result, many successful contractors have been reluctant to put their rigs on "day work" and prefer footage contracts.

What Can Be Done. The problem is, "how can operators and contractors establish a contract "climate" so contractors can reap enough added profits to make slim hole drilling attractive without assuming too much of the added risk?" The solution has not yet been found in most areas, but a modified footage contract is clearly indicated wherein operators shoulder at least part of the risk. Furthermore, operators must be prepared to accept somewhat greater hole deviations if they are to realize full economies of slim hole drilling. For years, a 3-deg maximum hole deviation was widely accepted. Today, thanks to API studies and progressive elements in the industry, widely different deviation limits are now being considered. Some operators are now considering allowing 7-deg or more maximum deviation provided the deviation is kept within 3 deg during any given 100 ft of hole.

Relaxed deviation limits promise to let both operators and contractors take full advantage of the economies inherent in slim hole drilling without unduly aggravating production problems. Some successful contractors, not currently engaged in slim hole drilling practices, have stated that they would seriously do so if they were permitted to bid in competition with big holes. If operators permit optional slimhole casing programs when calling for bids, they might realize some very attractive savings. Drilling contractors would then have added opportunity to realize fairer profits from their work.

It is not known at the present time which of the three paths discussed will be taken. It is known, however, that some changes are indicated. The earlier these changes are adapted, the greater will be the benefits to the entire industry. At the present time, certain producers who stand to realize great benefits from slim hole drilling are having difficulty in finding a good selection of competent contractors to bid on slim hole programs. It is of interest to producers and contractors alike to develop a "climate" conducive to the rapid development of slim hole drilling.

* * *

Dates Set for 1956 Permian Basin Oil Show

Dates for the Permian Basin Oil Show of 1956 have been set for October 18-21. The Odessa show will be held again at the Ector County Coliseum and Fair Park area.

Choice of 1956 show dates follows the custom of setting schedules to coincide with Oil Progress Week observances throughout the nation. In announcing dates following a special meeting of the Board of Directors, show manager Carlos M. "Cotton" Clover said that the 1956 show is expected to surpass all earlier shows.

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P 934.351

Technical assistance more in demand . . . here's what the drilling contractor is doing about the shortage

More Drilling Engineers Needed

WANTED

C. R. Graham
Field Editor

COMPLEXITY of operation and increased technological requirements of modern drilling, coupled with demands of management to meet competition, are putting the drilling engineer in a new position of importance in the contract drilling business.

A relatively new man on the scene, the drilling engineer is filling the bill in many new areas: Mud control, safety, fishing and hydraulics. In many instances, rig unitization, equipment service and maintenance and rig design are being added to his list of duties.

Unfortunately, procurement of men qualified to handle such operations is not easy. Drilling, refining, producing, petrochemical and transmission phases of the industry are competing for engineers in an open market—and then among each other—to obtain top-level personnel.

Demand has far exceeded supply. As the percentage of drilling by contract drillers, now nearing 93 per cent, increases, so grows the need. At present it is estimated that there is only one drilling engineer for each 100 rigs in the field. Nationwide, American industry has called for 30,000 new engineers this year, with only 21,500 graduates available to fill the openings. Engineer recruiting has become highly competitive. As a result, starting salaries are being raised and employees benefits are being heaped higher. According to figures of the American Management Association, this group is earning about 4.5 per cent more than it earned last year, with the average beginner receiving about $4500 a year. This figure is far below that offered by the drilling industry. Young men graduating from colleges and universities with degrees in petroleum engineering have their pick of the field. The trend today indicates that many of these students are more favorable to signing up with major companies, assured of security and "long-term benefits."

AAODC Program

With all these factors in mind, the American Association of Oilwell Drilling Contractors is engaging in a program to interest young men in choosing drilling as a profession, with progressive independence and unlimited opportunities.

AAODC has had much to base its case for a student choosing to follow a drilling career. Most men entering the industry just out of college can look forward to a period of extensive training at a relatively high pay scale.

Graduates, as a rule, are employed at a salary of $530 to $550 per month while serving as driller's helpers for a period ranging from one to two years, depending on the individual's qualifications, previous knowledge and experience. From this basic period, the engineer has many roads from which to choose. In any course, after two or three years, he may expect to draw a salary ranging between $700 and $800 monthly. He may follow the driller-toolpusher route into management or he may advance along the lines of drilling engineer and drilling superintendent. He feasibly may enter into the drilling contracting business in seven or eight years from the time of his entrance into drilling. Under any circumstance, the man with an engineering background is in a far better position to obtain financial security and business success due to the ever-increasing technological advancements in the drilling business and need for this type individual. New drilling techniques and advanced equipment, brought on by the need for faster, deeper drilling, and narrower margin of profits have necessitated engineering skills.

Recruiting at Campus Level

By the very independent nature of the drilling industry, no completely unified or concerted effort of personnel enlistment is possible. AAODC, however, has done much, not only in recruiting engineering students from the college campus into drilling work, but in pointing up the need for such personnel at every opportunity. It has sought to cultivate an understanding within the ranks of present drilling personnel of the engineering and technological demands necessary for intelligent, well-founded competition among contract drillers.

Perhaps the most effective work in agitating an interest in drilling work has been the presentation of honorariums to professors or instructors in various universities and colleges. It has focused attention of educators on this industry with a vast potential for engineering development.

AAODC has increased the number of honorariums offered each year to include five instead of three schools. This year, checks for $400 and commemorative plaques were presented to the following: Dr. Charles F. Weinaug of the University of Kansas; Professor A. W. Walker, of the University of Tulsa; Professor Philip Johnson of Texas Technological College; Professor A. D. Ford of the University of New Mexico; Professor Nico van Wingen; and Dr. Carroll M. Beeson of the University of Southern California.

To follow up these awards, stories and publicity were distributed to the press and trade publications. The need for engineers is being pointed up at every opportunity.

XUM

The association has gone far to furnish speakers for various seminars and special technical meetings. The need for drilling engineers has been voiced in programs at the University of California, University of New Mexico, Texas Technological College, Louisiana State College, the University of Tulsa, Kansas State College and Kansas University.

These seminars are paying dividends. Undergraduate students have gone so far as to write AAODC headquarters seeking employment.

Program Includes Training

To supplement the program of seminars and honorariums are a long list of films, books, brochures, and other services designed to interest the student.

Seven new sound films now are being completed to supplement an already large library. The latest films cover in detail these subjects: Cementing tools and equipment, cementing operations, electric logging, radioactivity logging, perforating, hydraulic fracturing and acidizing. These films alone represent an outlay of about $40,000 and were co-sponsored by various well service companies and the association. Most of them were prepared either by the University of Oklahoma or by the University of Texas Petroleum Extension Service.

AAODC has just underwritten a grant of $5000 to the University of Texas to further study its educational program, and has assigned its research and education committee the job to carry out its other work programs.

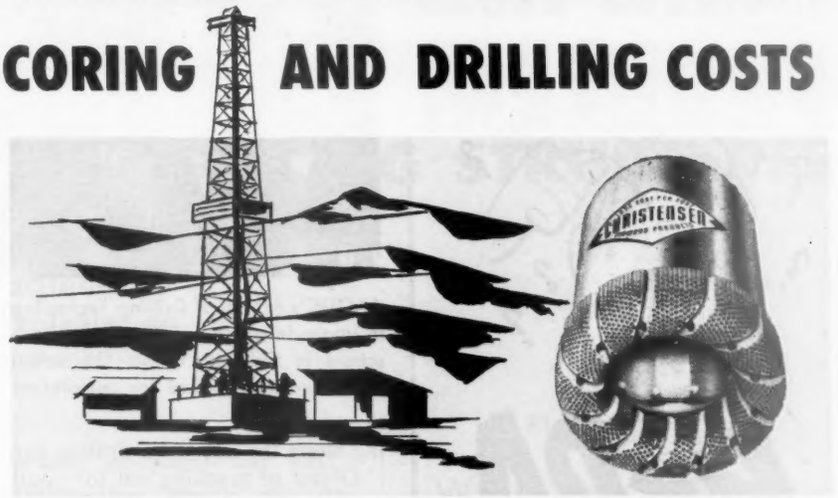
The association has made possible the purchase of its books, especially "Primer of Oil Well Drilling" and "Primer of Oil Well Service and Workover" at reduced rates. Many of these books are being used in many colleges and universities as texts or supplemental reading in petroleum engineering courses. Training aids and instructors are often "borrowed" for instruction in these courses. AAODC is working closely with several colleges in offering suitable instruction in drilling engineering.

During the past year, the appeal has been directed more toward the undergraduate, with the hope that by the time of graduation he may have elected and prepared himself to enter the drilling field.

Other Avenues Taken

A second look is being given to the junior college student and even the high school graduate, and there is some advancement concerning a movement, based on dissemination of information through brochures, existing films, speakers and exhibits, to channel think-

DIAMONDS WILL REDUCE YOUR CORING AND DRILLING COSTS



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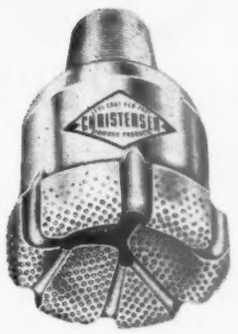

FORMATION BIT SIZE	TOTAL FOOTAGE	PENETRATION RATE	TOTAL COST	BIT COST PER FOOT	BIT LOAD POUNDS	RPM	FL. VOL.
BETHANY FIELD, PANOLA COUNTY, TEXAS							
Pettete and Travis Peak 6⅛"x3½" Core Bit	1000 ft.	4 ft./hr.	$1600.00	**$1.60**	6,000-12,000	60	200 gpm
WILDCAT FIELD, LINCOLN COUNTY, LOUISIANA							
Travis Peak 8⅝"x5¼" Core Bit	725 ft.	3 ft./hr.	$2145.30	**$2.96**	8,000-16,000	50-60	275 gpm
QUALEY DOME FIELD, ALBANY COUNTY, WYOMING							
Red Beds 6-3/16" Drilling Bit	638 ft.	2 to 3 ft./hr.	$ 846.05	**$1.33**	5,000-12,000	70	230 gpm
WERTZ FIELD, CARBON COUNTY, WYOMING							
Tensleep	408 ft.	1½ ft./hr.	$2187.11	**$5.34**	12,000	60	250 gpm

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. . . from ⅓ HP to 240 HP . . . from 20 bbls to 17,000 bbls . . . from 200' to 10,000' and more . . . Yes, a REDA may do that pumping job BETTER . . .

Reda Pumps are accepted as original equipment, or replacement equipment, because they produce at a lower cost per barrel of fluid. Whether it's large volumes from shallow depths, or modest volumes from great depths, Reda Pumps provide operating savings.

IMPROVED DESIGN:

Constant research and design improvement are responsible for lengthened operating life; corrosion resistance, low labor cost per barrel of fluid produced.

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Greatly improved overall efficiencies have improved Reda performance as much as 25%; a substantial operating saving.

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■

BARTLESVILLE, OKLAHOMA

AAODC's School of Drilling Technology is proving to be among the most popular courses to upgrade present drilling personnel. These are graduates of the first fall term, 1954 school in Odessa, Texas. The safety "hard hats," representing the school's mortar board, were awarded for completion of the course.

ing along the lines of a drilling career.

Object of reaching out for youth at such an educational level has many advantages. Foremost is directing a student considering engineering to develop a proper educational background in mathematics and physical sciences. More than one college upperclassman has found himself lacking in basic training when an alternate course of study was chosen, denying himself an engineering degree, as well as the drilling industry of potentially one less drilling engineer.

Long Range Steps

These are all long-range steps, designed to deliver qualified young men to the drilling contractor in 1957, 1958, and even 1960.

Realizing the immediate need, AAODC has undertaken a training program to educate present drilling personnel in the ever-changing advancements designed to speed-up, ease, make safer and by all means make more profitable the drilling operation. This program began in the early 1940's.

Extensive Training Program

AAODC's training programs were initiated in 1945 with the creation of an educational administrative committee. First interest were directed toward mud control and drill pipe corrosion, as suggested by the association-financed Battelle Institute studying drilling "gaps". As an outgrowth, the "Mud Manual" was written by Guy Mabee and E. F. Warren; the University of Texas established a mud research program; and a series of mud training schools have been conducted. Since its inception, the mud schools have been attended by almost 8500 men.

Second major step in the program was taken in February, 1947 by the research and education committee, formed at the Association's 1946 annual meeting. With the increase in deep drilling and its accompanying problems, a Drilling Practices Course was organized and was set up in cooperation with the University of Texas at Kilgore College. The second and third School of Drilling Technology was conducted at Odessa College. Both institutions have achieved outstanding success.

At the Management Level

In 1948, the idea of a series of Management Institutes was conceived and a program was set up to reach into management levels of the contract drilling industry. The following year a Drilling Engines Course was organized with a complete engines laboratory valued at $50,000 at its disposal. Accident Prevention Conferences were run in 1948 and 1949. A new short course to supplement the Employer Unit Plan of Supervisory Training was set up in 1951.

By May 1951, the organization had enrolled 12,799 in its courses at a presentation cost of $266,496. The number of men attending these courses are now estimated nearing the 15,000 mark.

Its School of Drilling Technology, offered at the fall and spring terms at Odessa College are opening up new horizons in upgrading drilling personnel.

The Association's programs are paying off. Public opinion of the drilling industry is running high. Employee turn-over is down; accidents have decreased; employment is up. Drilling advancements in technique and equipment innovation and improvement are continuous. Total number of active rigs is at a peak with unparalleled stability of operation. Outlook for the future is encouraging, both for present management and personnel with new opportunities for rising drilling engineers.

Acknowledgment

The author wishes to thank the American Association of Oilwell Drilling Contractors and those on the AAODC staff who generously supplied background information and basic data for this discussion. * * *

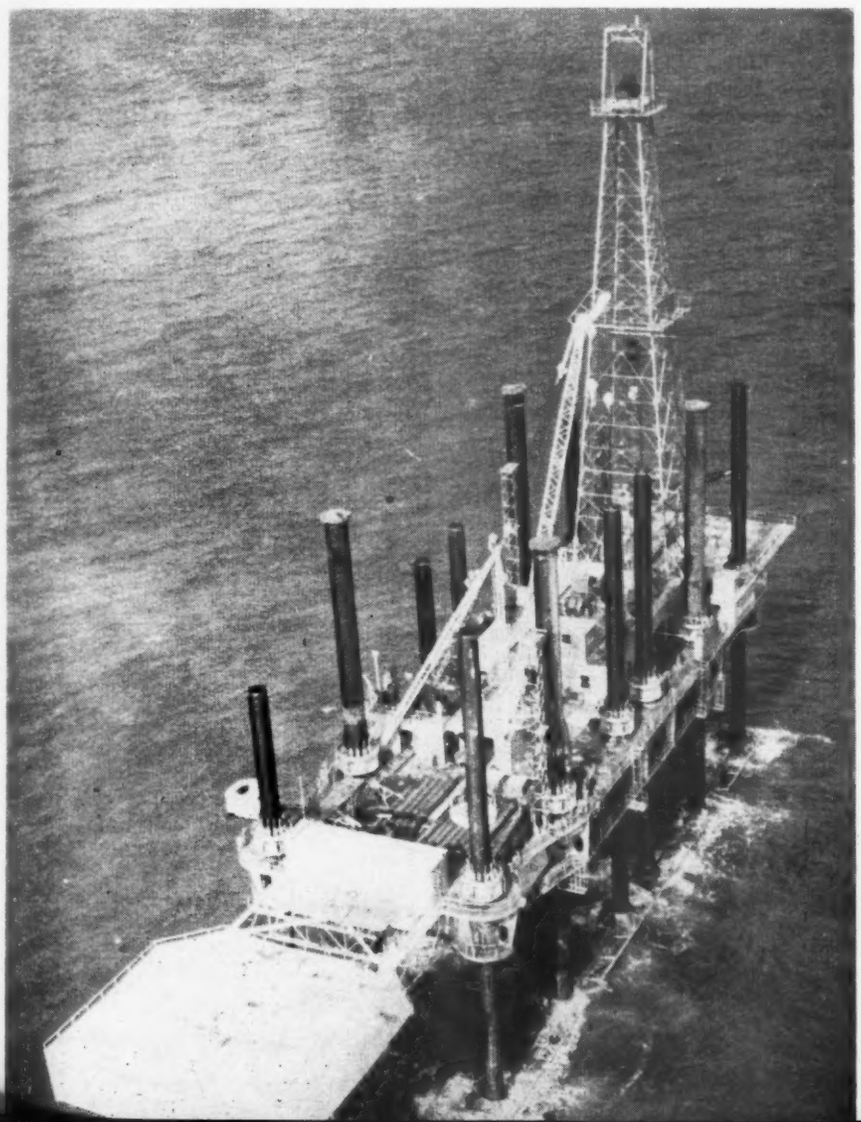
Part 1

Design of OFFSHORE DRILLING STRUCTURES

Wind and wave forces, soil reactions, internal effects and methods for calculating stability of mobile units are summarized

Editor's Note: This article was especially prepared for THE PETROLEUM ENGINEER, and contains the "meat" of the author's important report, Publication No. 8, of the Technical Services Division, Shell Oil Company, Houston. The full report was presented at the Ninth Annual Petroleum Mechanical Engineering Conference of the American Society of Mechanical Engineers.

Considerable study of forces, their actions and reactions, went into the design of "Mr. Gus," $3.5 million mobile drilling platform of C. G. Glasscock Drilling Company, first used by Shell Oil Company off the Texas Coast.



Richard J. Howe

WORLD-WIDE expansion of offshore drilling and production operations during recent years has generated considerable interest in the design of offshore structures. These structures are designed for a wide variety of conditions ranging from 6 to 8-ft maximum waves in Lake Maracaibo to 40-ft waves and 125-mph winds associated with maximum Gulf Coast hurricanes. There are a number of relatively indeterminant factors in offshore design, such as wave forces and soil reactions; however, there is a large amount of engineering information that can be used to good advantage until more theoretical, experimental, and operating information becomes available.

The basic approach is to divide all external forces that act on a structure into actions and reactions, with the actions being defined as forces that tend to move the structure and reactions as forces that resist the actions. Although the structure must be in equilibrium under the action of the external forces, there are internal effects such as stresses and deflections that also are very important. In addition to considering the actions, reactions, and effects, a general classification is presented to illustrate the relative advantages of different types of structures.

The Actions

All forces tending to move the structure may be defined as the actions and they include the static forces and dynamic forces. The static forces are well defined since they are essentially equal to the sum of the weights of the various components; however, the magnitude of the dynamic forces has not yet been defined with any degree of accuracy.

Static Forces. Static forces acting on a structure include fixed equipment weights, movable equipment weights, operating loads, and weight of the structure itself. As a general rule, these forces are not critical from a stress

standpoint because they generally represent a small percentage of the total stress; however, they often become critical from a soil-loading standpoint. The amount of equipment located on the structure depends upon whether it is a self-contained or tender-type structure. As the total weight of a structure can range from 700 to 6000 tons, no representative weights will be quoted.

Dynamic Wind Forces. The theoretical pressure imposed upon flat and curved surfaces by air moving at a given velocity is a function of the kinetic energy of the air. Expressed mathematically, this relationship is:

$$p \propto \frac{1}{2} \frac{w}{g} V^2$$

Where:

p = unit pressure, lb/ft^2,
w = specific weight of the air, lb/ft^3,
g = 32.2 ft/sec^2, and
V = velocity of the air, ft/sec.

The total force may be obtained by multiplying the kinetic energy by a dimensionless drag coefficient and the projected area:

$$F = \frac{1}{2} C_D \frac{w}{g} V^2 A$$

Where:

C_D = dimensionless drag coefficient, and
A = projected area, ft^2.

Substituting a value of 0.0765 lb/ft^3 for the density of air and converting the velocity to miles per hour:

$$F = \frac{1}{2} C_D \frac{0.0765}{32.2} \left(\frac{88}{60}\right)^2 V'^2 A$$

$$F = 0.00255\, C_D V'^2 A$$

Where:

V' = velocity of the air, miles/hr.

The Weather Bureau formula for calculating air pressures on flat surfaces can be developed by substituting $C_D = 1.5$ into the above equation:

$$F = 1.5 \times 0.00255\, V'^2 A = 0.00385\, V'^2 A$$

or:

$$F = 0.004\, V'^2 A$$

The Weather Bureau formula applies only to air moving at a given velocity impinging upon a flat surface. It is reasonable to believe that, during a hurricane, there is a good possibility that a certain amount of water could be entrained in the air. This water could originate from spray being carried along by the air or from rain, with the spray probably being the more important factor, as the amount of rain in one cubic foot of air at any instant is infinitesimal. Owing to the fact that the kinetic energy, and hence the total force, is a direct function of the density of the moving medium, a large increase in the density would cause a correspondingly large increase in the total force. In the case of water entrained in the air, this is quite easily accomplished because water is approximately 800 times more dense than air, and therefore even a very minute percentage of water by volume will cause a significant increase in the density of the mixture. It is interesting to note that water vapor in the air would actually decrease its specific weight because the molecular weight of water is 18 and the molecular weight of air is approximately 29.

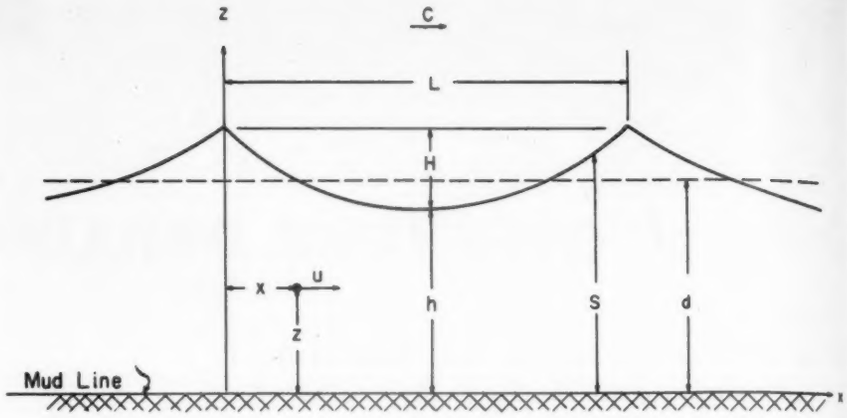


FIG. 1. Symbols used in wave force calculations are: C = wave celerity, ft/sec; d = design still water level, ft; h = trough elevation above bottom, ft; H = wave height (trough to crest), ft; L = wave length, ft; S = elevation of water surface above bottom, ft; u = horizontal particle velocity, ft/sec; x = horizontal coordinate, ft; and z = vertical coordinate, ft.

Dynamic Wave Forces. One of the most difficult problems is estimating, with a fair degree of accuracy, the wave forces imposed upon a structure by a given set of wave conditions. There has been more information published on wave behavior than on any other phase of offshore design, with the possible exception of soil mechanics; however, there is very little information available today on the correlation of the published theoretical and experimental information with the actual forces on offshore structures.

Four major wave theories are summarized from an engineering design standpoint: 1. Airy Theory covers small waves in all depth ranges except very shallow waves. 2. Solitary Wave Theory may be applied to periodic waves at or near the breaking point in shallow water. 3. Stokes Theory applies to a limited range of waves of medium height in deep and intermediate water depths. 4. Michell Theory applies to maximum waves in deep water. Reid and Bretschneider[1] used the above four theories as limiting cases and extrapolated the various parameters to cover intermediate conditions.

In general, the forces acting on a body subject to the action of a moving fluid can be divided into five principal classes: Drag, inertial, impact, differential pressure head, and momentum reflection forces. Wave symbols used are presented in Fig. 1.

Drag forces on a submerged object are a function of the kinetic energy of the fluid and are directly analogous to the drag forces associated with conditions of steady flow as described for wind forces. The drag force per foot on a vertical, cylindrical pile may be expressed as:

$$f_D \propto KE \times A$$

Where:

f_D = horizontal drag force per unit length of pile, lb/ft,
KE = kinetic energy per unit volume, ft-lb/ft^3, and
A = projected area per unit length, ft^2/ft.

Multiplying the above expression by a constant of proportionality, C_D, and substituting the pile diameter, D, for the area per unit length:

$$f_D = C_D \times KE \times D$$

or:

$$f_D = C_D \frac{w}{2g} u^2 D$$

Where:

C_D = dimensionless drag coefficient,
D = pile diameter, ft,
w = specific weight of the fluid, lb/ft^3,
g = 32.2 ft/sec^2, and
u = horizontal velocity of the fluid, ft/sec.

It should be noted that the velocity, u, is defined as the velocity that would be present at the center line of the pile if the pile were absent.

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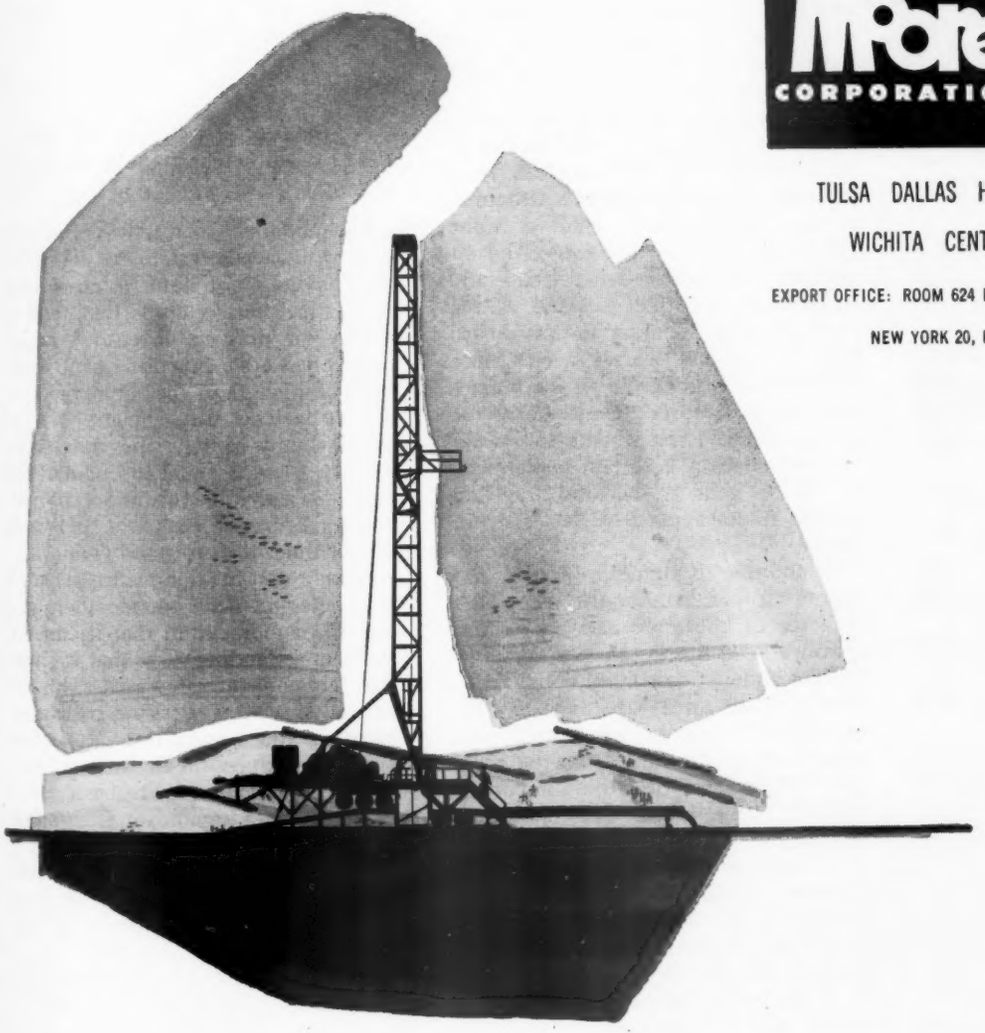

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In order to determine the total drag force on a pile, the unit drag force must be integrated over the length of the pile. Unfortunately, the horizontal particle velocity is not a constant, and therefore it must be left within the integral sign. The expression for theoretical horizontal particle velocity at any point depends upon the wave theory being applied. It is generally so complex that it cannot be integrated analytically. Therefore, the integral must be determined numerically or graphically. Also, the drag coefficient is a function of the Reynolds number, which means that it is also not constant; however, it is usually assumed to have a constant or mean value ranging anywhere from 0.33 to 2.0 for circular piles, with most designers using either 0.33 or 0.50. The expression for total drag force on a vertical, cylindrical pile is:

$$F_D = \pm C_D \frac{w}{2g} D \int_o^S u^2 \, dz$$

Where:

F_D = total horizontal drag force, lb,
S = elevation of water surface above bottom, ft,
z = elevation measured upwards from the bottom, ft, and
dz = increment of length in vertical direction, ft.

The maximum positive value of drag force occurs as the wave crest passes the pile, and maximum negative value when the trough passes.

Inertial forces on a vertical pile are a function of the product of the mass of the displaced fluid and acceleration of the fluid particles. The unit horizontal inertial force is:

$$f_i \propto ma$$

Where:

f_i = horizontal inertial force per unit length of pile, lb/ft,
m = mass of displaced fluid per unit length, lb-sec²/ft/ft, and
a = horizontal acceleration of fluid particles, ft/sec².

Introducing the proportionality constant, C_M,

$$f_i = C_M ma$$

or:

$$f_i = C_M \frac{w}{g} \frac{\pi}{4} D^2 \frac{du}{dt}$$

Where:

C_M = dimensionless mass coefficient,
w = specific weight of fluid, lb/ft³,
g = 32.2 ft/sec², and
D = pile diameter, ft.
$\frac{du}{dt}$ = horizontal acceleration of fluid, ft/sec².

Acceleration is defined as the horizontal particle acceleration that would be present at the center line of the pile if the pile were absent.

Total inertial force on a pile extending from the mud line to the surface of a wave, assuming that the mass coefficient remains constant, may be expressed as:

$$F_I = \pm C_M \frac{w}{g} \frac{\pi}{4} D^2 \int_o^S \frac{du}{dt} \, dz$$

Although the acceleration term can maintain a plus or minus sign by itself, a double sign is added to emphasize the point. The inertial force is zero at the crest and trough positions and is a maximum somewhere between the crest and half the distance to the trough.

As with C_D, the value of C_M is also not well defined. Laboratory experiments have placed the value of the mass coefficient somewhere between 1.30 and 1.70 with a value of 1.5 commonly used; however, recent experiments have indicated that these values may be too low.

Impact forces are generally associated with plunging or incipient breakers where the crest of the wave is flying through the air and strikes a structure, causing sudden shock loading. Some believe these forces are caused by air pockets trapped by flying water and compressed and then explode with a characteristic booming sound heard near breakwaters, sea walls, etc. Little information is available on the magnitude of these forces, particularly for circular piles. These impact forces are approximated as a certain percentage, say 20 per cent, of the total drag and inertial forces applied at the crest position.

In addition to the drag, inertial, and impact forces commonly associated with waves, there are also differential pressure head forces that are very important under certain conditions. Technically, these forces are primarily inertial, but it is more convenient to consider them as resulting from the pressure difference across the submerged object. These forces are important when there is a submerged object, such as a barge, which has a length parallel to the direction of wave travel that is significant in relation to the wave length. In this discussion, height of the object is assumed to be small compared to depth, so that the energy reflection forces may be neglected.

For a barge with length L_1 parallel to the direction of wave travel, width L_2, and height L_3, the force caused by a pressure head differential is:

$$F_P = L_2 L_3 (p_1 - p_2)$$

Where:

F_P = differential pressure head force, lb,
p_1 = gage pressure at leading edge of barge, lb/ft², and
p_2 = gage pressure at trailing edge of barge, lb/ft².

As the barge disturbs the pressure pattern, a dimensionless pressure coefficient, which is a function of the shape of the submerged object, must be added to obtain the true force:

$$F_P = C_P L_2 L_3 (p_1 - p_2)$$

Where:

C_P = dimensionless pressure coefficient.

In the case of a very small wave in shallow water, the pressure difference would be equal to the static head of water. For a barge that has a length equal to one-half the wave length, the total force for a very small wave would be:

$$F_P = C_P L_2 L_3 wH$$

Where:

w = density of water, lb/ft³, and
H = wave height (trough to crest), ft.

For moderate to large waves in both shallow and deep water, the above expression does not hold because there are vertical accelerations that tend to modify the pressure forces. Although these forces are a function of the water depth and length of the submerged object, as well as wave height, a good rule-of-thumb is that the differential pressure force is equal to one-half the static pressure difference (approximately 0.25 psi per foot of wave height) times the projected area.

When a non-breaking wave strikes a breakwater or plane barrier, there is a reversal of momentum that frequently results in a standing wave that is larger than the undisturbed waves. This reflection of energy exerts a moderate force on the breakwater. Reflection forces should be taken into account when a large submerged object has a height that is a significant fraction of the water depth.

The design still-water level is the basic water depth upon which all wave calculations are based. It may be defined as:

$$d \doteq d_o + A_t + S_t$$

Where:

d = design still-water level, ft,
d_o = mean low-water level, ft,
A_t = astronomical tide, ft, and
S_t = storm tide, ft.

Mean low-water level is given by U.

S. Navy navigation charts for any particular location or it can be determined directly by soundings that have been corrected for astronomical tide. The astronomical tide can either be measured directly or obtained from tables prepared by the U. S. Coast and Geodetic Survey.

Storm tides are considerably more difficult to predict. They are a result of three principal effects:

1. Mass transfer effect—water is piled up by wind action.
2. Manometer effect—water level rises due to a reduction in pressure at the storm center.
3. Surge effect—general movement or sudden intensification of a storm causes surges that raise the water level.

The design still-water level at any particular location should be evaluated by a competent oceanographer if it is a critical factor in the design of a structure for that location. This evaluation involves determining the probability of a certain set of meteorological conditions occurring, and then applying various theories to find what storm tide will result.

The maximum height that a wave can attain in a given depth of water is limited by dynamic stability considerations. The maximum wave in shallow water is defined by the solitary wave theory as:

$$H_{max} = 0.78\ h$$

Where:

H_{max} = maximum wave height (trough to crest), ft,
h = elevation of wave trough above bottom, ft.

The maximum wave in deep water is:

$$H_{max} = \frac{1}{7} L$$

Where:

L = wave length (crest to crest), ft.

In general, waves break when the particle velocity at the surface of the wave exceeds the celerity or velocity of the wave itself. Waves breaking in shallow water, which have been generated in deep water, tend to break with a characteristic plunging action, whereas those generated in shallow water usually break in a spilling manner.

Current forces on an offshore structure are steady flow drag forces caused by moving water. The total force exerted on a circular pile is:

$$F_C = \frac{w}{2g} D \int_o^S C_D\, u^2\, dz$$

Where:

F_C = total current force, lb,
w = specific weight of water, lb/ft³,
g = 32.2 ft/sec²,
D = pile diameter, ft,
S = elevation of water surface above bottom, ft,
C_D = dimensionless drag coefficient,
u = velocity of the current, ft/sec, and
dz = increment of length in vertical direction, ft.

If the drag coefficient and current velocity can be expressed by a constant or mean value over the pile length, the following expression can be used:

$$F_C = \frac{w}{2g} DC_D\, u^2 S$$

Surface currents along the Gulf Coast can be as swift as 1 mph. The force exerted on a 3-ft pile in 20 ft of water by a uniform 1-mile current, assuming a C_D of 0.5, would be:

$$F_C = \frac{64}{2 \times 32.2} \times 3 \times 0.5 \times \left[\frac{88}{60} \times 1\right]^2 \times 20 = 64 \text{ lb.}$$

As the force exerted on the same pile by a maximum solitary wave in this depth of water would be on the order of 12,000 lb, the current force alone would not be significant from an overall design standpoint.

Earthquake conditions present on the Pacific Coast must be considered in the design of offshore structures for that area. Although forces exerted by an earthquake on an object standing in water have not been evaluated completely, an approximate method used is to assume a lateral force equivalent to one-tenth to two-tenths of a "g" applied to the structure mass. For a structure weighing 3000 tons, this would amount to a lateral load of 600 tons for a force of 0.2 g. As the probability of an earthquake occurring during maximum wind and wave conditions is remote, Pacific Coast structures are generally designed for either earthquake or storm conditions, but not for both conditions occurring simultaneously.

The Reactions

Reactions may be defined as all forces that oppose the actions, and they include soil forces and buoyant forces. Soil reactions are perhaps the most critical factor in overall design of all types of offshore structures. But, there is much to be learned about predicting the behavior of soils, particularly the lateral behavior.

Buoyant forces are not too important a factor in the design of a structure in place; however, they can become a very critical factor during moving or installing structures, particularly mobile units.

Soil Forces. Four general methods can be used to determine mechanical properties of soils:

1. Dynamic pile-driving formulas, 2. Small test piling, 3. Full-size test piling, and 4. Soil coring and analysis.

Dynamic pile-driving formulas predict the ultimate capacity of a pile by the number of blows necessary to drive the pile a unit length. These dynamic pile formulas apply to only a very limited range of conditions, and are particularly useless for friction piles in soft silt or clay. These formulas should not be used to predict penetrations until one pile has been driven and tested at the particular location.

Use of small test piles is of limited value for predicting performance of larger piles; however, penetrations of small piles, which are often driven to support coring platforms, may be of use in correlating results obtained from laboratory analysis of cores. Use of full-size test piles will give vertical capacities of piles accurately with a minimum of equipment; however, lateral behavior is more difficult to determine owing to the large amount of instrumentation involved. These full-scale tests, which are generally as expensive as coring, also may be used to evaluate time effects on pile capacity and pulling resistance.

Use of soil borings and laboratory analysis to aid in overall design of a piling installation is perhaps the best and most accurate method. These surveys, of necessity, are quite expensive; however, improved methods of moving coring equipment on location, such as mobile coring units, could reduce the cost appreciably. Laboratory tests of cores can be used to predict not only the initial vertical and lateral capacities of soils but also final capacities after the soils have reconsolidated.

Soils may be divided into cohesionless soils such as sand, and cohesive soils such as clay. Resistance of clay soils is primarily a function of their cohesive shear strength whereas the strength of sand is a function of the angle of internal friction and normal force.

Vertical soil reactions may be divided into skin friction forces and bearing forces. Piles are supported by skin friction and/or point bearing, whereas barges, etc., are supported vertically by bearing reactions alone. There are a number of problems associated with vertical reactions such as settlement and scour that are of considerable importance. The bearing capacity and settlement of barges can be predicted with a fair degree of accuracy by means

of well-established foundation formulas. The amount of scour that will be experienced by all hull-type mobile units appears to be a very important factor and its effects will also have to be evaluated when more operating and experimental information is available.

Lateral soil forces may be divided into compressional reactions and shear reactions. Compressional forces are lateral forces exerted on piling below the mud line, and they are believed to be a function of the type of soil, size of pile, and amount of deflection. Shear forces are lateral forces that hold barges and other objects resting on the ocean floor in place by means of the soil's shear capacity, which is a function of the type of soil and normal force.

Predicting elastic forces exerted on piling by soil is one of the most important factors in the design of a majority of offshore structures. One approximate method that has been used is to assume an equivalent point of fixity at some distance below the mud line and to calculate stresses and deflections by neglecting soil resistance above the point of fixity. Another approach, which considers the pile as a beam whose loading is proportional to deflection, uses a soil modulus concept. In general, the soil modulus is a function of the type of soil, depth, pile diameter, and deflection. One analytical method assumes that the soil modulus is constant. This assumption makes it possible to obtain a general solution for the moments, shears, and deflections. Perhaps the best numerical method for predicting lateral behavior of piling was summarized by Sol Gleser.[2] A difference-equation approach is used that is perfectly general in that variable soil moduli and pile section moduli can be easily introduced. If soil modulus values can be evaluated accurately for different soils and pile sizes by means of full-scale testing and soil sampling, the difference-equation method will become very valuable to offshore designers.

Buoyant Forces. One of the important factors in the design of offshore structures, particularly the mobile, submersible-hull drilling units, is buoyancy. This buoyant force is a direct result of the pressure difference acting across the immersed body, and therefore it is equal to this pressure difference multiplied by the projected area as well as the weight of fluid displaced. To illustrate this point, a vertical cylinder passing through a container of water displaces water; however, there is no buoyant force, because there is not necessarily a pressure difference across the cylinder. In most cases, the buoyant force is equal to the weight of liquid displaced. A good average value for sea water density is 64 lb/ft^3 as compared to 62.4 lb/ft^3 for fresh water.

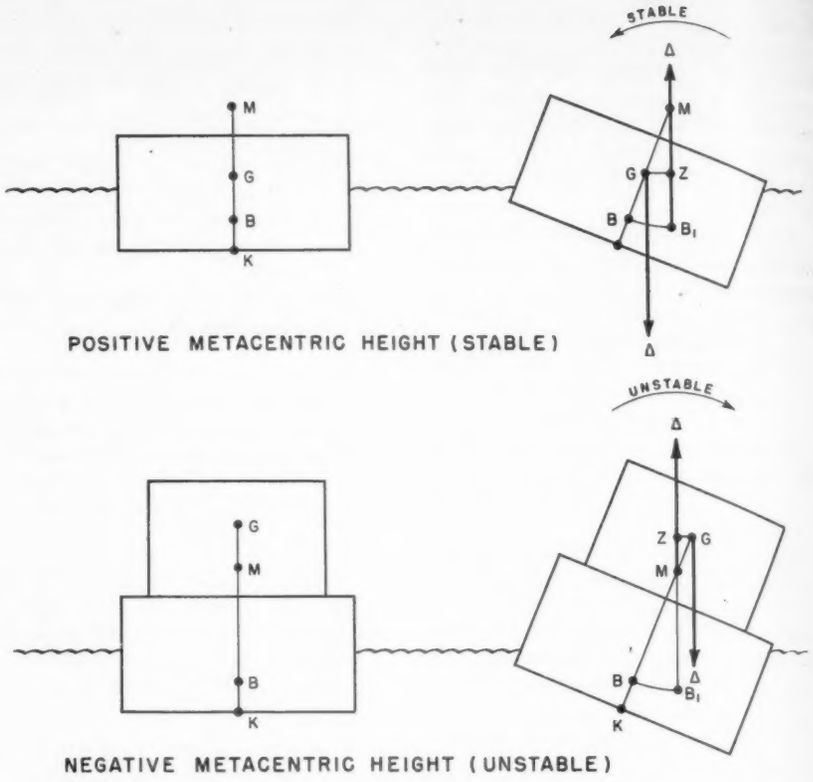

FIG. 2. Stability of floating mobile units are determined by their metacentric height, GM. If it is positive, the unit is stable; if negative, as shown below, it is unstable.

Any freely floating body is in equilibrium under action of two equal and opposite forces: (1) Weight of the body acting downward through the center of gravity, and (2) buoyant force acting upward through the center of buoyancy. In general, the center of gravity of any given body has vertical, longitudinal, and transverse coordinates. In the case of offshore mobile units, weight is usually distributed symmetrically with respect to the longitudinal axis, thus eliminating consideration of the transverse center of gravity.

A measure of the stability of a floating object is its transverse metacentric height. If the metacentric height is positive, the object is stable. If it is negative, it is unstable, as illustrated in the upper part of Fig. 2. The metacentric height is a function of the vertical center of gravity, vertical center of buoyancy, moment of inertia of the water plane area, and volume of water displaced. Although stability increases with metacentric height, the natural period of roll decreases and gives poor riding characteristics. For this reason, the metacentric height of ocean-going passenger vessels is usually on the order of 2 ft whereas offshore mobile units have a metacentric height ranging from 30 to 600 ft. Referring to Fig. 2, the metacentric height GM may be expressed as follows:

$$GM = KB + BM - KG$$

Where:

M = the metacenter,
B = the center of buoyancy,
K = the keel or bottom, and
G = the center of gravity.

Thus,

KB = distance from the keel or bottom to the vertical center of buoyancy, ft,
BM = transverse metacentric radius, ft,
KG = distance from the keel or bottom to the vertical "center" of gravity, ft, and
GM = metacentric height, ft.

It should be noted that KB and BM are a function of the geometry of the vessel and KG is a function of weight distribution within a vessel.

The center of buoyancy of rectangular vessels is equal to one-half the draft, and for vessels of irregular shape, is equal to the sum of the products of each volume and its distance above the keel divided by the total volume.

The transverse metacentric radius is a function of the water plane moment of inertia and displacement volume.

$$BM = \frac{I}{V}$$

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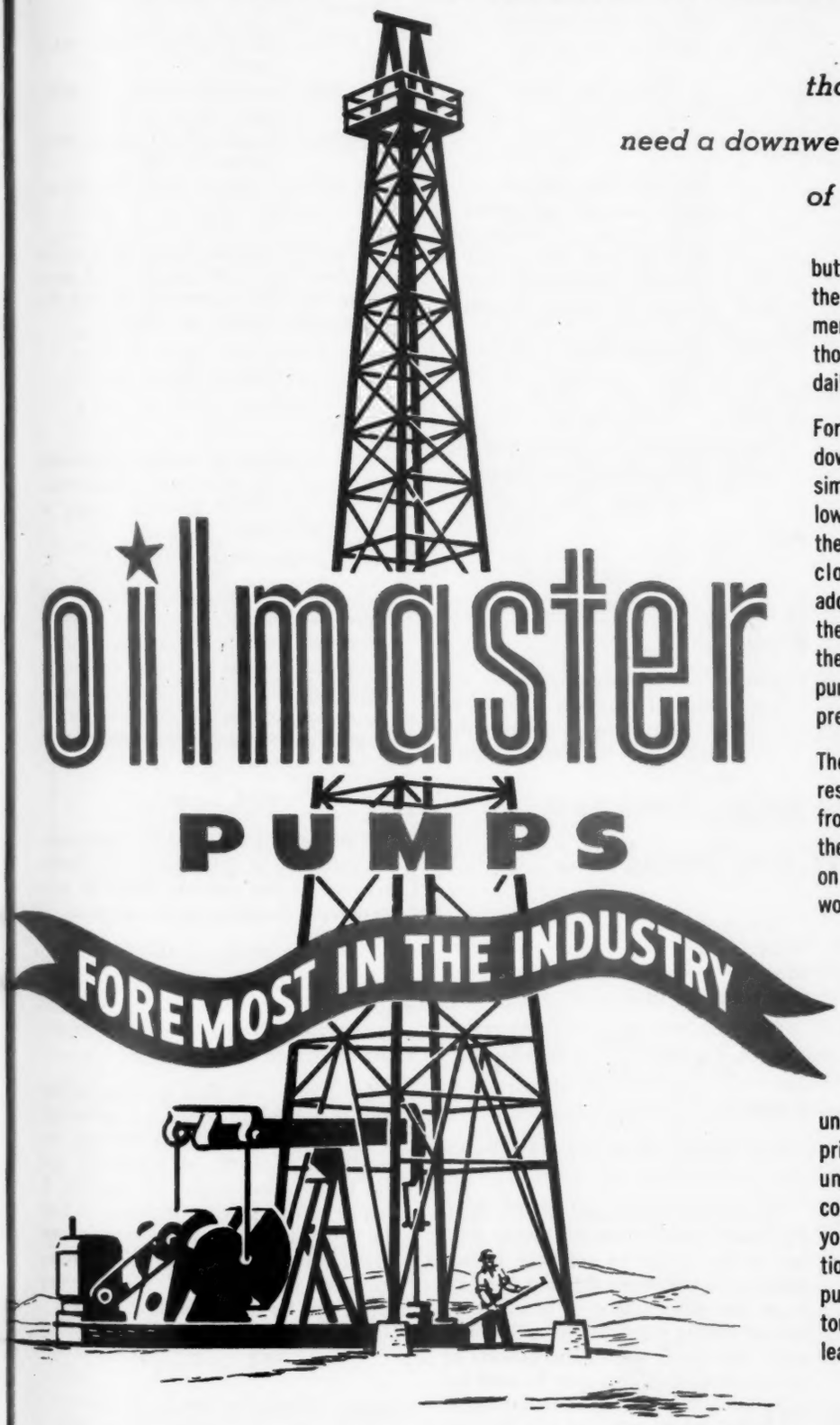

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The combination achieved some interesting results. With the top of the plunger protected from the high pressure fluid in the tubing, the pump couldn't pound fluid. The fluid load on the hollow polished rod did the necessary work of compressing the gas and transferring the fluid from the pump barrel to the annular chamber on the downstroke, and in addition it kept the rods in tension.

We could go on — lower load range on the rods meaning lower torque on the unit gear box and less horsepower from the prime mover. No more gas lock meaning more uniform production, less destructive heat converted in the pump. But we suggest if you are interested in more efficient operation than you can obtain from a conventional pump in gassy or foamy wells that you get in touch with your Oilmaster representative and learn all about the

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Where:

I = moment of inertia of the water plane area about the longitudinal axis, ft⁴, and
V = displacement volume, ft³.

The vertical center of gravity may be obtained by dividing the sum of the products of each weight and its distance above the keel by the total weight.

Although the metacentric height is a measure of stability, a better indication of the stability is the righting moment. In general, the righting moment increases as the angle of heel increases until the water plane area, and hence the water plane moment of inertia, begins to decrease, causing the metacentric height to decrease proportionately. Referring to Fig. 2 where the vessel has been displaced an angle Θ, it can be seen from the geometry that:

$$\frac{GZ}{GM} = \sin \Theta$$

It follows that the righting moment is equal to the displacement Δ times GZ, as the gravity force acts downward through point G and the buoyant force acts upwards through point B_1.

$$RM = \Delta GZ = \Delta GM \sin \Theta$$

Where:

RM = righting moment, ft-tons,
Δ = displacement, tons,
GZ = righting arm, ft,
GM = metacentric height, ft, and
Θ = angle of heel, radians.

If the vessel under consideration has ballast or liquid storage tanks that are partially filled, a free surface correction must be made because liquids in these tanks shift when the vessel is tipped. To avoid the problem of a free liquid shifting, tanks may be pressed full, and then no free surface correction is necessary. Actually, the free surface correction amounts to decreasing the metacentric height by an amount equal to the moment of inertia of the free surface area about a longitudinal axis through its center divided by the vessel's total displacement volume. Expressed mathematically this is:

$$GM_s = GM - \frac{i}{V}$$

Where:

GM_s = metacentric height corrected for free surface, ft,
GM = metacentric height considering liquid volume as a solid, ft,
i = moment of inertia of liquid surface about a longitudinal axis through the center of area of that surface, ft⁴, and
V = total displacement volume, ft³.

The natural frequency of floating objects is also important when the wave frequency is in the same range. Neglecting damping, the equation of a ship's motion is:

$$I \frac{d^2\Theta}{dt^2} + RM = 0$$

Where:

Θ = angle of heel, radians,
I = mass moment of inertia of ship about a longitudinal axis through the center of gravity, ft-tons-sec², and
RM = righting moment, ft-tons.

For small inclinations:

$$RM = \Delta GM \Theta$$

Where:

Δ = displacement, tons, and
GM = transverse metacentric height, ft.

Also:

$$I = \frac{\Delta k^2}{g}$$

Where:

g = 32.2 ft/sec², and
k = radius of gyration of mass of the ship about a longitudinal axis through the center of gravity, ft.

Therefore:

$$\frac{d^2\Theta}{dt^2} + 32.2 \frac{GM}{k^2} \Theta = 0$$

This is the equation for simple harmonic motion where the frequency is equal to $\frac{1}{2}\pi$ times the square root of the coefficient of Θ:

$$f_n = \frac{1}{2\pi}\sqrt{32.2 \frac{GM}{k^2}} = 0.9 \frac{\sqrt{GM}}{k}$$

Where:

f_n = natural frequency of roll, cycles/sec.

The longitudinal stability of a floating vessel, which is usually not as critical in the design of offshore mobile units as the transverse floating stability, is an important factor in determining the stability of submersible-hull mobile units when they are in the process of end-on sinking. It also may be used for calculating the trim of all mobile drilling units and vessels that are floating. The longitudinal metacentric height is a measure of longitudinal stability and it is a function of the center of buoyancy, moment of inertia of the water plane area about the transverse axis, volume of water displaced, and the vertical center of gravity. The transverse metacentric height may be expressed as follows:

$$GM_L = KB + BM_L - KG$$

Where:

GM_L = longitudinal metacentric height, ft,
KB = vertical center of buoyancy, ft,
BM_L = longitudinal metacentric radius, ft, and
KG = vertical center of gravity, ft.

The longitudinal metacentric radius is a function of the longitudinal water plane moment of inertia and the displacement volume as follows:

$$BM_L = \frac{I_L}{V}$$

Where:

I_L = longitudinal moment of inertia of water plane area about transverse axis through center of buoyancy, ft⁴, and
V = displacement volume, ft³.

As the longitudinal metacentric radius is generally large (in order of one to two times the length of the ship) compared to the vertical center of buoyancy and vertical center of gravity, an approximate expression for the longitudinal metacentric height may be given as follows:

$$GM_L \simeq BM_L$$

The righting moment in a longitudinal direction is developed in a similar manner to the righting moment in a transverse direction. It is equal to:

$$RM_L = \Delta GZ_L = \Delta GM_L \sin \psi$$

Where:

ψ = longitudinal inclination, radians.

In order to calculate the longitudinal trim of a floating vessel it is necessary to determine the distance between the longitudinal center of buoyancy and the longitudinal center of gravity. It can be shown that the moment to trim the vessel 1 in., that is, to decrease the bow freeboard by ½ in. and increase the stern freeboard by ½ in. or vice versa, can be expressed as follows:

$$MT_1 = \frac{\Delta GM_L}{12\,L}$$

Where:

MT_1 = moment to trim the vessel 1 in., ft-tons,
Δ = displacement, tons,
GM_L = longitudinal metacentric height, ft, and
L = length of the vessel, ft.

If the distance between the longitudinal center of buoyancy and the longitudinal center of gravity is designated by n, then the trim may be expressed as follows:

$$t = \frac{\Delta n}{MT_1} \frac{12\,Ln}{GM_L}$$

Where:

t = trim in inches, and
n = distance between the LCB and LCG, ft.

Range of stability (number of degrees that a mobile unit can be inclined before it capsizes) is one of the more important stability considerations. As the determination of this range involves a rather lengthy series of trial and error calculations, it will not be discussed in this presentation. As a general rule, most mobile units have a range of stability of about 20 deg and an initial metacentric height of approximately 50 ft, whereas ships have a range of stability on the order of 75 deg and an initial metacentric height of about 2 ft. Fortunately, the two factors are complementary and there is a very close correlation between the total energy required to overturn ships and mobile units.

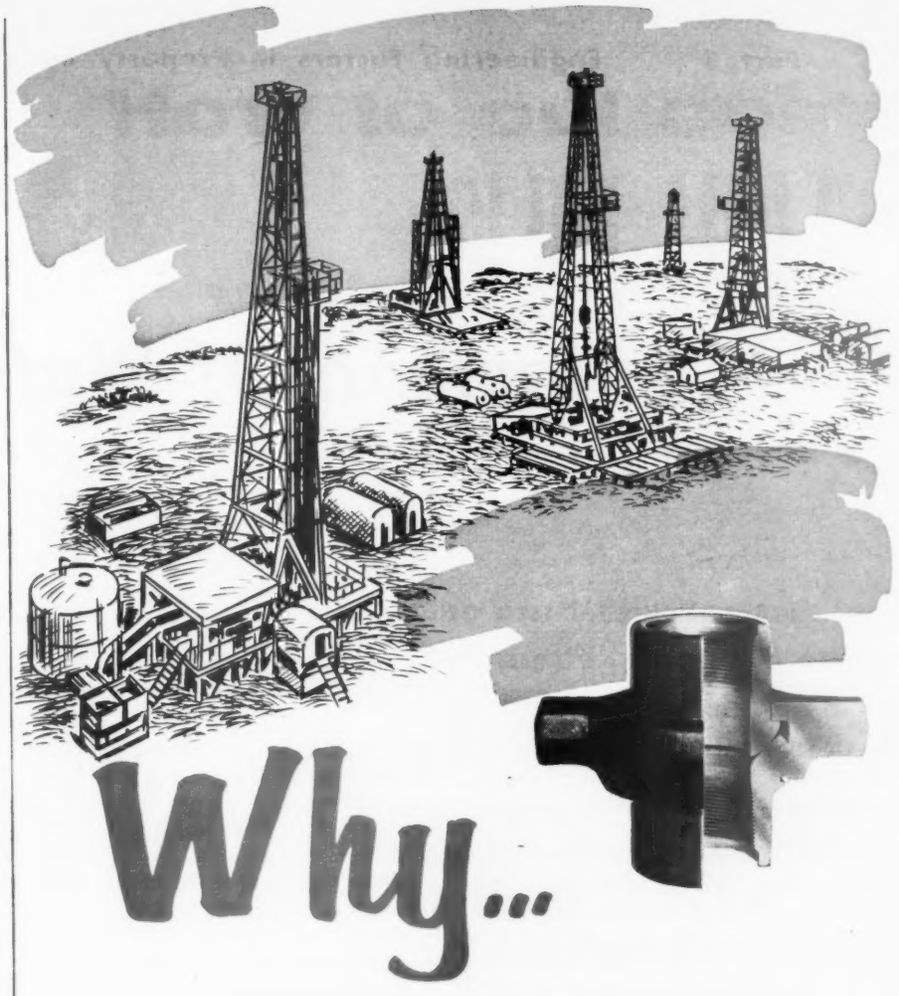
The Author

Richard J. Howe received his Ph.D. in mechanical engineering from the University of Minnesota and shortly thereafter joined Shell Oil Company in its technical services division at Houston, Texas. For approximately the past two years, he has concentrated his efforts toward offshore structure design and development. Prior to joining Shell, he was an instructor in mechanical engineering at the University of Minnesota.

References and Bibliography

References and bibliography will be presented at the end of Part II which will follow in the November, 1955, issue.

Part II of this discussion will deal with the deflections and stresses caused by external forces. Equations will be developed for natural frequencies of some typical structures. In addition, a classification of offshore structures to compare engineering characteristics of various designs will be given.



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Part 3 **Engineering Factors in Property Selection**

Elements of Water Injection

- **Field Observations**
- **Coring**
- **Laboratory Tests**

J. Randolph Buck
Consultant, Dallas, Texas

FLOODING preparations are a matter of using to the fullest extent every scrap of information available, obtaining essential data on your own initiative when not otherwise available, or doing without as a calculated risk. Information on many of the older producing areas is both poor and incomplete. In such cases, the decision to try a flood is sometimes made on the basis of neighboring successes. In most cases, a coring program can correct the data deficiency. For the more recent fields, data are usually in better shape. Pressure and production history, electrical logs, and some core analyses often can be located. Where this is the case, some worthwhile opinions as to floodability can be formed. Field data provide indications as to basically favorable or unfavorable subsurface conditions.

Reservoir Pressure Data. Detailed records of static reservoir pressure with time are a good indicator of the continuity of permeability and its directional aspects. Where pressures have held relatively uniform throughout the field at the time of each general survey, reasonably high and continuous permeability can be assumed. If the pressures at certain wells were consistently below average, however, and were reflected as pressure sinks on the isobaric maps, then poor sand development or other barrier to the free flow of fluids can be suspected. Such wells would make poor choices for injection service. The crowding together of isobaric contours delineates the least desirable portions of the field.

Bottom-hole pressure buildup curves for individual wells are used in the calculation of average permeability in the well's drainage area. A comparison between premeability so calculated and that calculated from productivity index tests provides an indication that formation plugging may have occurred near the well bore if the buildup data points to a substantially higher value. The deviation between calculated permeability and that from core analysis is similarly revealing.

Initial Completions. In the study of initial completions of field wells, it is interesting to note that wells were completed with water base mud easily and with uniform potentials and gas-oil ratios. The inference herein is that silt and bentonitic particles will not present a problem during subsequent water injection.

Water History. Detailed water production records by wells are most valuable. The degree of activity of a partial water drive can be estimated, as can the direction of the source of natural water and the progress of the water throughout the oil-bearing zone. The mere presence of water is not a flooding deterrent. Rather, it is the quantity and distribution of invading water during the primary history that affects the decisions. Needless to state, a significant water cut in the majority of wells, despite a solution gas drive type of pressure decline, would impress unfavorably even the most venturesome flooder.

Abandonments. Careful attention should be directed toward the location and methods employed in the abandonment of old producers on or near the property of interest. The need for bracketing the producing horizon from below and above was not appreciated in earlier days. Ineffective plugging practices represent potential hazards from natural flooding of producing sand through the well bore by other ground waters and also the loss of oil and injection water through similar paths in the reverse direction. Many operators can be thankful that they reentered and plugged old wells.

Previous Injection. Acreage is avoided where flooding has already been practiced updip. This situation is encountered in those older broad areas of production such as the Bend Arch Province of North Texas or the northeast Oklahoma Platform. Water from the updip flood may have gravitated through permeable zones to establish water saturated streaks in the planned flood.

Whether previous injection of air or gas as a recovery measure adversely affects recovery by waterflooding is debatable. Recognizing that some very successful floods have been conducted following gas injection, it can be stated that the previous drive reduced the oil saturation and, accordingly, increased the permeability to water in the critical, most permeable zones. The dangers can be minimized by not using the former gas injection wells for water injection purposes. In this way, fluids can be made to deviate from the formerly established flow paths. Air injection carries a particular disadvantage due to its capacity of oxidizing some components of crude oil and thereby increasing oil viscosity.

Fracturing. The subject of the effect of hydraulic fracturing techniques on secondary recovery is receiving much attention at the present time. Both suc-

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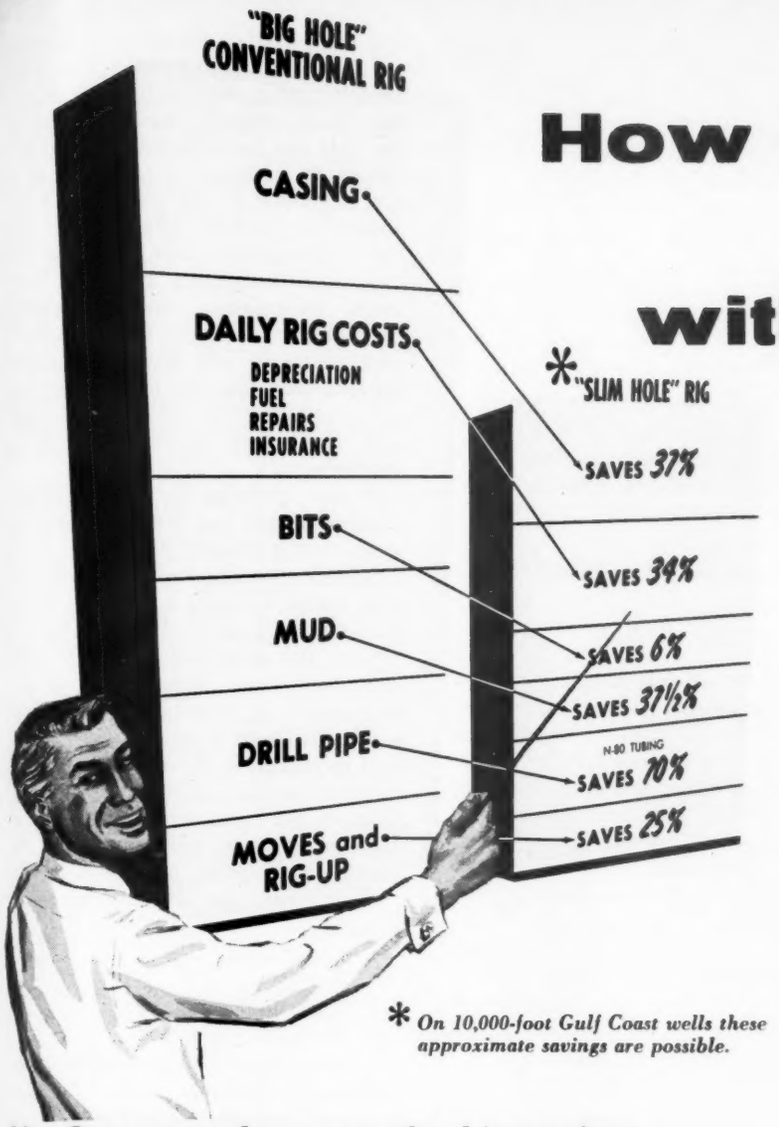

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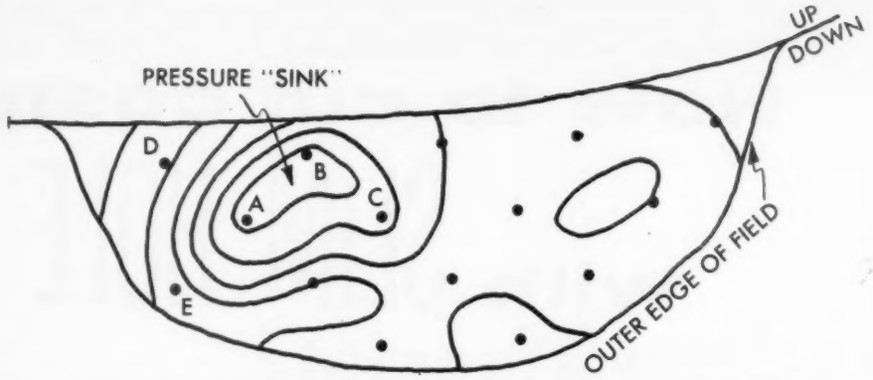

Isobaric map indicating continuous sands over the eastern half of field. The western portion with its pressure sink appears less favorable, possibly due to shaly sands or a minor, undetected fault west of Well A. Injection into Well A would effect Wells B and C, but not Wells D and E.

cesses and failures, with and without fracturing, have been demonstrated. Purely from the standpoint of the reasonableness of the practice, it would seem that any fracturing method that caused radiation of fractures extending great distances between injection and producing wells is unquestionably harmful to waterflooding. On the other hand, fracturing methods that create numerous vertical fractures, each of short radial length, not only should do no harm but, contrarily, be of advantage in flooding tighter pays. The answer to the fracturing question will not be "yes" or "no," but rather will depend on how the job was done and for what purpose.

Coring

Obtaining and analyzing cores from the field is a widely recognized method for obtaining information essential to the prediction of secondary recovery. Although all cores, however obtained, have utility in the determination of permeability and porosity, the age and condition of cores and the drilling fluid used control the specialized results that can be obtained. The best core is one with 100 per cent recovery, fresh, and uncontaminated by the drilling fluid.

Example of the use of unit injectivity capacity is demonstrated in the calculations below.

Unit Injectivity Capacity = 0.0002 bbls per day per millidarcy-ft per pound sand face pressure (laboratory determination).

Given:

Permeability to Water	= 30 millidarcys.
Net Thickness	= 1000 ft.
Depth	= 15 ft.
Injection Pressure at Surface	= 200 psi.

Therefore:

Hydrostatic Head	= 440 psi. (0.44 psi/ft.)
Sand Face Pressure	= 640 psi. (440 + 200)
Injection Rate	= (0.0002) (30) (15) (640)
	= 57.6 bbls per day per well.

For depleted sands, some of the most satisfactory coring has been done with electric coring devices for the reason that the hydrostatic head of liquid in the hole can be adjusted to equal the formation pressure, even when at a very low value. Flushing of cores in the absence of pressure differentials is unlikely. Rotary and cable tool cores are those most frequently available. Very useful information can be obtained from chip cores. Cores from low pressure zones are the most satisfactory because they lose the least oil by expansion during the reduction of pressure from that in the reservoir to atmospheric.

If the problem is to determine whether a sand has been saturated by water during primary production or by accidental flooding, then oil or oil base mud should be used in coring. Air or gas when used as the drilling fluid will prevent the possibility of liquid contamination from either water or oil-base muds. If residual oil saturation is desired, then a water base drilling fluid should be used. When fresh cores cannot be made available, plugs can be cut from old cores and re-examined in the laboratory to yield important information. Principal objectives in laboratory work are to determine the following:

1. Permeability,
2. Porosity,
3. Interstitial water,
4. Initial oil saturation,
5. Residual oil and total liquid saturations after flooding,
6. Unit injectivity capacity,
7. Reaction of fresh water,
8. Relative permeability characteristics.

Importance of the first four have previously been discussed.

Laboratory Investigations
Residual Oil Saturation

Residual oil saturation that exists after flooding is determined from flood pot tests. This experiment reproduces the flooding process. Although techniques vary between laboratories, the general procedure is described. A plug is cut from the field core, cleaned by Soxhlet extraction, then saturated with reservoir or synthetic brine. Oil (or kerosine) then is forced under pressure into the plug to reduce the brine saturation to the point where no further brine can be ejected. This is the irreducible water or connate water saturation by the restored state method. The next step is to displace the oil by the appropriate injection water thereby simulating actual flood condition.

Water is admitted and the test continued until some arbitrary terminal condition is reached. For example, the test might be run until the outgoing

water-oil ratio reaches 25, or until say 40 or 50 pore volumes of water had been passed through the core. With knowledge of the total oil injected into the core in the restored state operation and of the total oil removed in the pot test, the oil remaining in the core after the miniature flood is readily calculated as the difference and expressed as a fraction of the total pore volume, that is, the residual oil saturation.

It should be recognized that results of a flood pot test on a single core are of true significance only to that infinitesmal part of the reservoir represented by that core. Obviously, the more separate plugs tested from various areas of the field the more credible are the results. It should also be recognized that results of flood pot tests tend to represent the maximum possible good that can be achieved in the field for the reason that the tests are customarily conducted using higher pressure gradients and larger volumes of water than can be realized in the field.

Judgment Factor. Some form of judgment factor must be applied to laboratory data for the purpose of estimating field recoveries. The fact is that all portions of the reservoir cannot be flushed down to the residual oil saturation indicated by the pot test. Allowance for this is sometimes made through application of a sweep efficiency factor that is the ratio of the reservoir volume that can be effectively flushed by the invading water to the total reservoir volume. Other engineers prefer to apply a general efficiency factor, obtained by practical experience in similar fields. This latter factor does not specifically relate to the assumed areal distribution of the water between injection and producing wells.

Water Fillup Volume. Determination of total oil and water saturations after pot testing of fresh cores provides excellent information for the calculation of total water required in the field to fill existing void spaces. As from 5 to 25 per cent of pore space still will be filled with gas even after flooding, actual water required to fill the reservoir will be less than would be anticipated by assuming that total porosity will be liquid saturated.

Injection Well Capacity. Unit injectivity capacity may be defined as the volume of brine that can be injected per unit sand thickness per millidarcy per pound of pressure applied at the sand face. This factor can be determined in the laboratory or else estimated on the basis of previous experience with similar permeabilities. Results are used in calculating the quantity of water per day that can be handled by injection wells under assumed conditions of applied pressure. Future oil production rates depend upon water injection rates, so the injectivity factor is exceedingly useful in well spacing and productive life computations.

Fresh Water Reaction. In test No. 7 (under coring) fresh water is passed continuously through the cores to detect any loss of permeability with time. A reduction in permeability may be attributed to the swelling or dispersion of clay content. An adverse reaction on this test requires that brine rather than fresh water be injected in the field.

Relative Permeability. Although test No. 8 (under coring), the determination of relative permeability, is desirable in evaluating the flood prospect, additional expense of these tests is usually avoided in assembling data for smaller projects. Relative permeability relationships provide a basis for detailed theoretical work directed toward the prediction of future producing water-oil ratios and ultimate oil recovery. Uncertainties concerning permeability distribution horizontally and vertically within a sand body in the field have the effect of discrediting purely theoretical conclusions when the quantity of basic data is limited.

Part 4 in this series will discuss those factors pertaining to planning a flood. These are: Types of floods, significance of gas cap, and sweep efficiencies.

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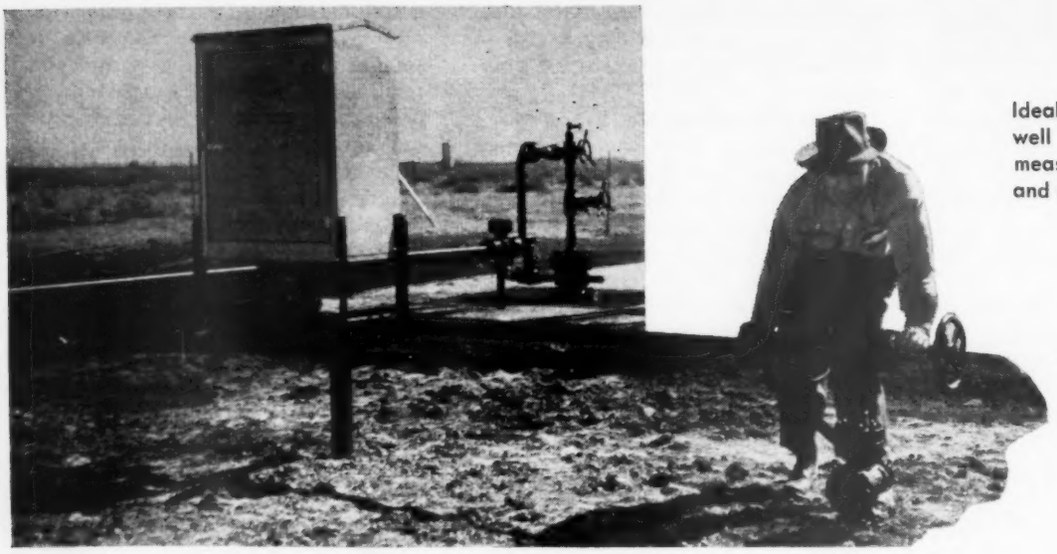

Ideal situation in measuring full well stream is to have point of measurement at the wellhead and upstream from the choke.

A Practical Approach to the . . .

Measurement of Full Well Stream Gas

Tips for Accurate Metering of Wet Systems With Conventional Methods

Joe Askew, Jr., L. G. Cable*

CORRECT measurement within limits of industrial practices of full well stream gas or wet gas is possible by orifice meters through conventional meter runs. Full well stream measurements in this manner presents some problems, most common of which are: (1) Hydrates forming in the meter (2) liquids collecting in the meter (3) slugging or pulsating flow (4) fluid condensing in the meter run and damming up in the upstream section of the meter run, and (5) obtaining correct wet gas gravities.

With the exception of an accurate wet gas gravity, effect of the problem stated above in most cases can be minimized or removed entirely by installing the measurement equipment as near the well as possible. Maximum temperature and pressure present at the wellhead can be used to prevent liquid drop out that ordinarily occurs when pressure and temperature are decreased from wellhead conditions.

*La Gloria Oil and Gas Company, Corpus Christi, Texas.

Gas measurement problems are complex due to the many variables involved. They become even more complex with the measurement of full well stream gas, which means in majority of cases on the Gulf Coast, the measurement of high pressure wet gas.

There are many theories and practices in existence today pertaining to this problem, some of which are very technical. It is the intent of this paper to approach the measurement of full well stream gas and some of the problems that affect good gas measurement, from a practical standpoint.

The main reason for full well stream gas measurement is that when combined with a GPM test, it is the most economical means to measure both gas and liquid from a well, where several wells are producing into a centralized separator or processing plant, as in the large cycling plants.

During the period of reservoir cycling, accurate or good wet gas measurement was not of particular importance in some plants because all residue gas was injected into reservoirs that were being cycled, and the only actual gas disposed of was that used for fuel. With the introduction of sales of large volumes of natural gas to transmission lines delivering gas to the northern and eastern parts of the country and to in-

Based on paper presented by authors at 10th Annual Short Course on Gas Technology sponsored by the Division of Engineering, Texas College of Arts and Industries, Kingsville, Texas, June 1-3, 1955

dustry moving to the areas of unlimited field supply, the necessity for accurate gas measurement became more important.

Measurement of well stream gas has been accomplished satisfactorily by the separation of gas and liquid at each individual well, metering each volume individually and recombining the liquid and gas before going into the gathering system. Equipment necessary to do this results in an expensive operation if several wells are involved.

Ideal Conditions

The ideal situation, from the standpoint of measurement, is one in which proper temperature and pressure exists at the point of measurement so that all liquid being metered is in the gaseous phase. The only point where these conditions could exist in a wet gas gathering system is at the wellhead.

A typical wellhead measurement installation is one in which the meter run comes directly off the wellhead with no choking or restrictions upstream of the orifice fitting. All flow control or choking equipment in an installation of this kind would occur downstream of the meter run.

With this ideal situation in mind, it would appear that if wet gas were metered at the wellhead, measurement would be no different than conventional dry gas measurement, and frequently this is the case. Anyone who has had experience with gas well production and wet gas measurement knows, however, that in the case of partially depleted gas wells, low deliverability wells that flow erratically, extremely high GPM wells, and others, the ideal conditions of pressure and temperature do not always exist and some fluid is produced at the wellhead. Therefore, the problems mentioned earlier that affect good wet gas measurement still must be reckoned with.

Hydrates

Because of the mild climate on the Gulf Coast, little trouble from hydrates will occur if proper operating practices are exercised. In this area, with the exception of low deliverability wells, most wellhead flowing temperatures are high enough that when the orifice meter is mounted so that the meter, orifice fittings, meter leads, and a part of the meter run are enclosed in an insulated meter house, enough heat radiates from that part of the meter run inside the house to prevent hydrates from forming.

Examination of hydrate expectancy curves indicates that as pressure increases, the point of hydrate expectancy is approached. For example, no hydrates will form with a .600 gravity gas at 60 F and 600-lb pressure. If

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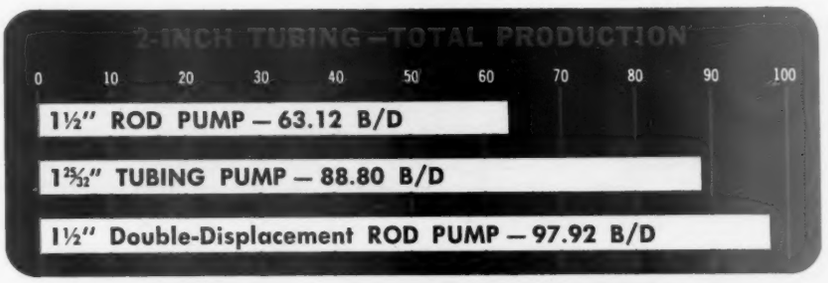
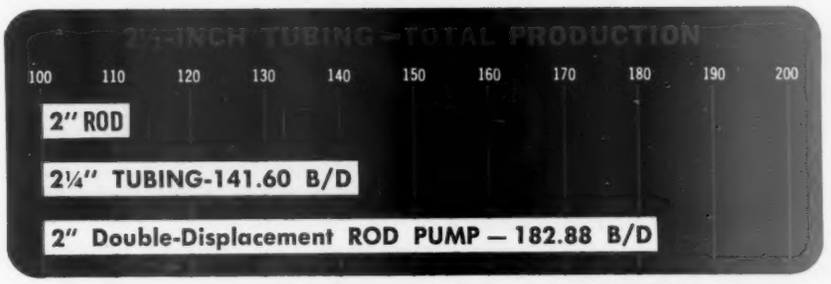
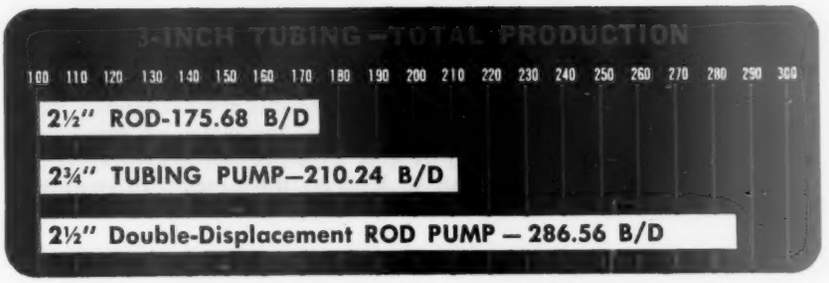

2-INCH TUBING—TOTAL PRODUCTION
0 10 20 30 40 50 60 70 80 90 100
1½" ROD PUMP — 63.12 B/D
1 25/32" TUBING PUMP — 88.80 B/D
1½" Double-Displacement ROD PUMP — 97.92 B/D


2¼-INCH TUBING—TOTAL PRODUCTION
100 110 120 130 140 150 160 170 180 190 200
2" ROD
2¼" TUBING-141.60 B/D
2" Double-Displacement ROD PUMP — 182.88 B/D



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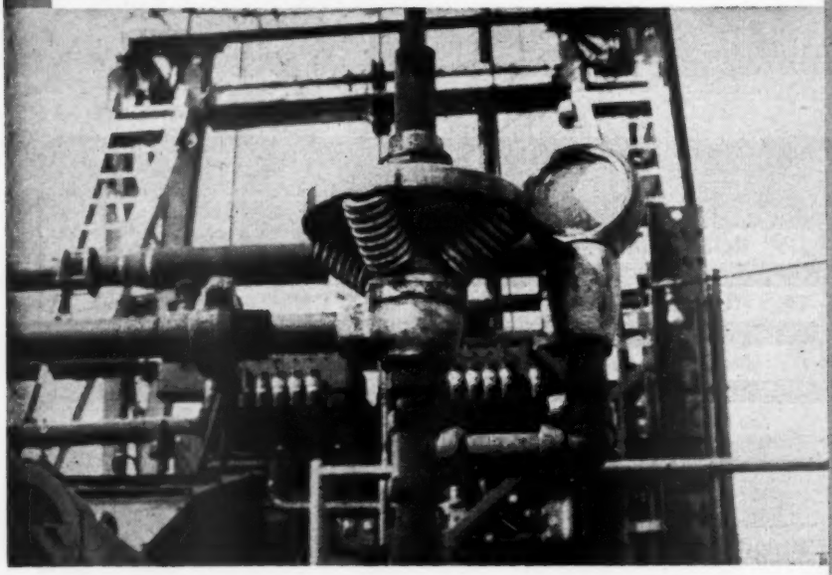

When overloads occur, the Kinzbach Model 112 Valve relieves the system instantly of the overload surge. Line pressure is maintained at a pre-set level, thus reducing the danger of a blowout. And, in case of momentary blockage, circulation is restored immediately, eliminating the danger of suspended cuttings settling and causing stuck pipe.

If the system overloads repeatedly, the 112 Valve will cycle rapidly without chattering and without damage, and without dropping the line pressure below the pre-set level, until the cause of the overload can be removed. Pump surges, which can be as high as 40% over normal pressure, do not affect valve operation so long as the proper valve for the service is selected and the pop-off pressure is properly set.

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pressure on the same gas were raised to 1000 psi, hydrates would form at 60 F.

Since most full well stream gas is measured at a relatively high pressure, the potentiality of measurement error due to hydrate formation is always present. The effect that hydrate formation in the meter body has on measurement depends upon the location of the hydrate formation. Hydrate formation around the flow linkage or in the pressure-tight bearing will lock the differential in one position, thus indicating a constant differential, and the meter will not pick up any change in actual differential. Hydrate formation blocking the meter leads will cause a differential pen to over-range or ride below zero, depending upon which meter lead is blocked. In either case, considerable error is introduced. With experience, presence of hydrates can be detected by examination of the chart, especially if the examiner is familiar with the producing characteristics of the well involved. When a meter freeze-up does occur, the meter usually can be cleared by releasing the pressure allowing the hydrates to melt. If the hydrates do not melt immediately, allow the meter to set under atmospheric conditions for a few minutes, and they usually dissipate.

The problem of hydrates is easily controlled if a source of heat is available to keep meter and meter leads warm. If natural heat is not available, as mentioned earlier, it is sometimes possible to induce artificial heat if power is available, such as installation of electric coils in meter houses to prevent hydrates.

Fluid in Meter

The problem of fluid in the meter body can be held to a minimum by preventing leaks in the meter manifold, piping, manifold valves, and especially pressure-type bearings. Theoretically, the only time flow occurs in the meter leads is when the meter is pressured up and placed into service; this in itself deposits some fluid in the meter body. If a leak in the meter or manifold occurs, it will cause a flow of wet gas in the meter leads and condensation of fluid in the meter body, resulting in an error in the differential reading.

A meter that has fluid in the upstream pot will give a high differential reading and one with fluid in the downstream pot will read low. With the exception of extreme fluid condensation, this differential error, which is constant at any differential range with a given amount of fluid, can be corrected by zeroing the meter under its respective operating pressure.

Systematic zero tests also will tend to correct any differential error due

to the change of this fluid level that may have occurred in the meter since it was last tested. This is done by most meter men at least once a week. In cases of extreme fluid condensation, the fluid will have to be removed from the meter as there is a limit to the amount of correction possible with the mechanical zero. It is also a good practice periodically to clean the meter pots and mercury, remove any liquid, and check the meter calibration. In most cases, the frequency of this service is set by contract or operating agreement, usually quarterly. Experience will indicate if more frequent service is necessary.

Pulsations

The problem of pulsation in full well stream measurement usually is attributed to intermittent liquid production. This condition exists in wells having a high liquid content, where deliverability is low or where flow rate is so low that liquid drops out in the well tubing and is produced as one slug of liquid. These examples exist in most cases in wells producing from partially depleted reservoirs or from large annular area casing completions.

In some cases where a well might flow with these characteristics at low rates, pulsation can be eliminated by increasing the flow rate. This is dependent upon the individual well. Under pulsating conditions of flow, an accurate chart reading is very difficult to obtain. This chart reading can be improved by sizing a meter run to have a high beta ratio and a high differential. A high beta ratio and high differential actually do not alter the pulsating flow but do reduce the width of the recorded differential such that some of the guess work on where to calculate the chart is removed.

Conditions that cause pulsation also can cause a more serious error of fluid building up in the upstream section of the meter run.

Liquid in Meter Run

In wells where the ideal conditions of pressure and temperature discussed earlier do not exist and the liquid is present in the liquid state in the well effluent, some liquid will drop out and dam up in the upstream section of the meter run. This condition results in the gaseous part of the well effluent passing through what amounts to a reduced diameter in the meter run. This effect will produce a low differential reading because the beta ratio existing in the meter run partially filled with fluid is higher than the ratio used in calculating the coefficient. A meter run sized to produce a high beta ratio and a high differential will minimize this error except in cases of extreme fluid build-up. Some experimenting has been done with the eccentric orifice plate to alleviate this condition. Principle of this plate is to install the orifice flush with the bottom of the meter run, thereby providing a free exit for the liquid to pass through without the damming effect.

Unlike the concentric plate, which has been the subject of exhaustive test work resulting in highly accurate and empirical coefficient data, the eccentric plate has no published empirical coefficients. A usable, reasonably accurate coefficient can be calculated by using a curve developed by L. K. Spink and the empirical coefficient for the same size concentric orifice plate. The resultant coefficient is higher than the concentric plate coefficient by .5 per cent to 3.5 per cent depending upon the beta ratio and Reynolds number involved. Principal objections to the eccentric plates are the difficulty in machining the plate and the extreme care necessary in installing the plate properly. Further development of eccentric orifice coefficient calculations should be watched so that the use of these plates, where necessary, could be advocated in contracts and gas gathering agreements.

Wet Gas Gravity

Determination of the gravity of a gas that contains no liquid can be accomplished easily by measuring that gravity with the gas balance. This method is not possible with wet gas because of liquid condensing in the balance when a sample is introduced. When this occurs, there no longer is a representative gas sample in the balance, and at the same time an error may be introduced by liquid depositing on the float to change the balance point.

The most accurate means of obtaining a correct full well stream gravity is from a fractional analysis. This is accomplished by calculating the molecular weight of the well effluent and comparing it to that of air. For example:

	Mol fraction	Molecular weight	Molecular value
C_1H_4—	92.42	16.042	14.826
C_2H_6—	4.23	30.068	1.272
C_3H_8—	1.62	44.094	.714
C_4H_{10}—	.38	58.120	.221
C_4H_{10}—	.52	58.120	.302
C_5H_{12}—	.22	72.146	.158
C_5H_{12}—	.14	72.146	.101
C_6H_{14}+	.47	86.172	.405
	100.00		17.999

Molecular weight of gas = 17.999 / Molecular weight of air = 28.966 = .621 specific gravity

Most gas gathering contracts require that gravity be obtained periodically, usually monthly or quarterly. If a large number of wells are involved and a fractional analysis necessary in each case, it would be both expensive and time consuming to determine the full well stream gravity by this method.

The most practical method of determining a full well stream gravity and one that is widely used is from the calculated formula found in the Railroad Commission Back-Pressure Test Handbook. Information required is: (1) The gas liquid ratio of the well (2) gravity of the liquid, and (3) gravity of the corresponding residue gas.

Formula:

$$\text{Sp Gr} = \frac{Gg + \frac{4591\ G_l}{Ra}}{1 + \frac{1123}{Ra}}$$

Where:

Gg = residue gas gravity
G_l = Specific gravity of condensate
Ra = Gas liquid ration, cu ft/bbl

Example:

$$\text{Sp Gr} = \frac{.620 + \frac{4591 \times .7467}{116{,}660}}{1 + \frac{1123}{116{,}660}} = \frac{.649}{1.0096} = .643$$

Data necessary to calculate this wet gas gravity can always be obtained from the periodic GPM test data. This testing is required of all wells producing wet gas into a common gathering system for the purpose of allocating liquid production and not for the sole purpose of wet gas gravity determination.

No attempt will be made to enlarge on the published information on deviation from Boyles Law. It is advised, however, that calculations be made to determine the accuracy of the critical temperatures and pressures established for each particular gravity.

In the higher gravity ranges, it is possible to have several hydrocarbon mixtures that will result in the same calculated wet gas gravity but have different critical temperatures and pressures. Naturally, this will affect the F_{pv} factor. The critical temperature and pressure for any mixture can be accurately calculated from a fractional analysis. This is important in that the flowing conditions under which most full well stream measurement occurs fall in the higher super compressibility factor ranges.

Not Only Method

All of the problems of full well stream measurement are by no means solved here and it is realized that other methods of solving the problems mentioned may be just as effective. It is thought that reasonably accurate measurement may be obtained if common sense and good judgment are used and the principles of good gas measurement are kept in mind. * * *

New approach to the . . .

Economic Selection of High Strength Casing

Comparison of price unit strength aids in cutting casing costs

J. W. Peret
Sun Oil Company, Dallas, Texas

CONTINUED deeper drilling depths, characteristic of recent years, has imposed the need for tubular goods with strengths superior to that provided by current API specifications. With respect to casing, this need has not been met in several ways, including the fabrication of high strength couplings, increased wall thickness, and the use of higher yield materials. The end result is the availability of so many different kinds of casing that the selection of casing in string design has become more difficult and time consuming.

"High strength casing" as referred to here is defined as any casing having strengths that exceed API specifications in collapse, burst, or tension.

Quantitativily, the operator is concerned in obtaining casing that will provide strengths adequate to satisfy the known or expected well conditions. Further it is desired to procure these strengths at a minimum economic investment, and particularly so for those wells having depths, severe temperatures and pressures that demand the more expensive high strength casing. Thus, in the routine procedure of string design the engineer is confronted with several requirements:

1. Selection of tubes with adequate strength for: (1) Collapse at the bottom of the string, (2) tension at the top of the string, and (3) burst in the center of the string.
2. Selection of tubes that provide these strengths at minimum costs.

To amplify the above, it is convenient to consider the wide and appreciable variation that exists in the economics of casing strengths. The following tabulation has been prepared, considering 7-in., 26-lb tubes, which have a minimum yield strength of 80,000 psi or more:

Column 1 shows that collapse strength varies from a minimum of $37.80 to a maximum of $56.70 per 100 psi of resistance, a range of $18.90.

Column 2 shows that the cost of coupling pullout strength per 1000 lb ranges from $0.400 to $0.585, a range of $0.185.

Column 3 shows that burst strength varies widely, from $33.20 to $41.60 per 1000 psi of burst resistance, a range of $8.40.

The suggestion inherent from the above is that casing string cost economy may be realized by:

1. Use of casing for the bottom of the string that is most efficient in collapse strength.
2. Use of casing for the top of the string that is most efficient in tension strength.
3. Use of casing for the center of the string that is most efficient in burst resistance.

Employment of steps 1, 2, and 3, would constitute "selective design" by reason of the fact that for each portion of the string (i.e. top, middle, and bottom) precise selection is made of the particular kind of casing that offers maximum economy and efficiency, as opposed to the use of casing selected for strength alone.

Of interest is a comparison of the cost of a selectively designed string vs strings composed entirely of one kind of casing. A set of hypothetical well conditions are assumed, including 12,000 ft TD, 16#/gal mud, and 7-in. casing, and design factors of 1.125 in collapse, 1.00 in burst, and 1.80 for minimum coupling pullout. A strength cost analysis was made for all weights of 7-in. casing for the kinds of casing labeled A, B, C, D, and E as shown in Tabulation A in order to facilitate the selective design of a casing string. Finally all strings were priced, delivered at Corpus Christi, Texas, representing a typical center of drilling activity, and which would reflect laid down prices at or near the rig. The following tabulation shows comparative costs of the strings.

Tabulation A.

Casing	Column 1 Cost/1000 psi of collapse resistance	Column 2 Cost/1000 lb of minimum coupling pullout	Column 3 Cost/100 psi of burst resistance
A	$37.80	$0.531	$40.75
B	50.70	0.585	37.25
C	46.55	0.548	33.20
D	56.70	0.400	41.60
E	50.25	0.469	36.40

From the above it is apparent that significant savings can be made by the economic selection of high strength casing. The responsibility of design personnel includes not only the provision of adequate casing strengths, at minimum cost, but also the development and maintenance of adequate records to permit conventional design procedures to be executed quickly and conveniently.

The following is suggested as a proposal to the above and has been done, serving very satisfactorily to date.

1. Prepare tabulation x for all sizes, all weights (vertically) and listing all kinds of high strength casing (horizontally). On this tabulation, record all published values for collapse, tension, and burst.
2. Prepare tabulation y for all of above tubes, showing price per 100 ft at some selected central point of drilling activity, which

EXCLUSIVE

Tabulation B.

String number	Casing string	String cost $	Relative per cent	Differential cost	Degree of economy
1	Selective	$40,755	100% Base	—	First
2	A	41,808	102.2%	$1,053	Second
3*	B	45,443	11.1%	4,688	Fourth
4	C	42,796	104.8%	2,041	Third
5*	D	48,222	118.2%	7,467	Sixth
6	E	46,878	114.5%	6,123	Fifth

*Note: Deficient in design factors using strongest tubes.

should include mill price, barge cost, and trucking cost.

3. Prepare tabulation z, which shows the respective quotients of entries in y divided by corresponding entries in x.

Casing design procedures will be greatly augmented by the preceding tabulations. After individual calculations have been made using well data and strength requirements estimated, from tabluation x all possible candidate casings may be quickly spotted. From this group, the most economical casing can be selected quickly at a glance from tabulation z. Each section of the string can be quickly and accurately determined and the resulting casing string will be at minimum cost. The design operation will have been carried out in one single straightforward convenient operation.

A survey was made covering five kinds of casing for which strength values in collapse, tension, and burst had been published; sizes considered were 4½ in. through 9⅝ in. inclusive, and all applicable weights. Some of the findings that emerged from this comprehensive survey are:

1. For a given size and weight pipe, say 7 in., 26 lb, it was found that casing A was most efficient in collapse; casing D was most efficient in tension; where casing C was most efficient in burst (see Tabulation A).
2. At the time of this writing it was developed that no one make or design of casing provided maximum efficiency in as many as two types of stress (burst, or collapse, or tension).
3. It was developed that the kind of casing that excelled with maximum efficiency in one weight may or may not excel in other weights.

In order to benefit from selective casing designs, it is necessary that pipe stocks be maintained, ready for use. This may at times present a sizable problem in respect to procurement policy and procedure. On operations of sufficiently large scale, the possible economic gain will normally justify the purchase of casings selected in design.

Other Factors

Following are additional considerations that exert a considerable influence on casing performance and therefore merit attention.

Casing Head Slip Suspension. With the advent of deeper wells and heavier strings, the industry has experienced repeated cases of wellhead slips crushing or "bottlenecking" the suspended casing. Preventive measures to avoid such failure include:

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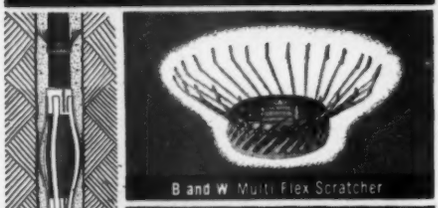
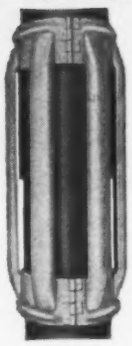
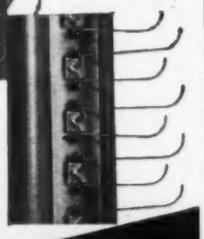

B and W Multi Flex Scratcher

B and W Hinged Nu Coil Scratcher


B and W Plain Stabilizer

B and W Latch-on Centralizer with Kon-Kave Bow

Multi-Flex Type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1. Use only those wellheads capable of satisfactorily suspending the casing load. This may be determined from load curves made available by the wellhead manufacturer.
2. Use one to two joints of casing taken from the strongest section at the top of the string for hanging purposes. In addition to serving as a "no-go gage" to prevent running oversize tools, it provides maximum resistance to collapse imposed by casinghead slips.

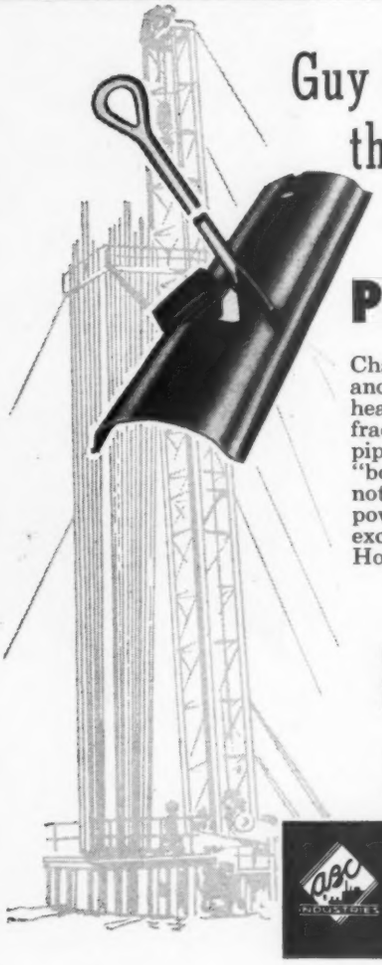
Casing Head Mounting. Casingheads are normally mounted by thread connection on the surface casing. The combined landed weight of all smaller casing strings, tubing string, and tree or preventers, are transmitted in the form of compressive stress directly to this connection. With increasing depths, the combined weights can cause thread failure, allowing the casinghead to strip-over the surface pipe. This type failure may be avoided by:

1. Taking the sum of the landed weight of all casing strings, tubing string, and BOP's. and comparing it with the manufacturers safe strength value for casing threads in compression.
2. Where necessary, surface strings should be provided with greater strength, or heavier wall to provide suitable safety factors in compression. Allowable wall thickness is, of course, limited by needs for clearance of preferred bit sizes.
3. Where the strongest acceptable casing will not provide adequate thread resistance to compressive loading, brandenheads equipped with circular baseplates supported by a substantial concrete block have been used successfully. Underfooting for the concrete block normally does not constitute a problem. Where low-bearing soil values are suspected, however, this can be checked against API Standard 4-A.

Drill Pipe Wear. Wear of casing strings by drill pipe tool joints can cause severe damage to casing rendering it useless for pressure confinement. Experience has shown that use of drill pipe centralizers having a diameter of at least ¼ in. or more greater than that of the tool joint, and so maintained by periodic examinations, has given successful protection to the casing.

Acknowledgment

Appreciation is expressed to the management of Sun Oil Company for permission to publish this article. * *



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COSTS

William P. Clements, Jr.*

SUPPOSE that you had a rig down and that a person or persons unknown to you backed a truck up to the location and made off with part of your equipment. That equipment represents money and you may just as well have had so much money taken from your safe. Or, suppose that you lose an equal amount of money through the use of operating procedures which could be improved upon profitwise.

Both of these suppositions are alike in that a certain sum of money is lost, but there the similarity ends. In the first, it is discovered immediately and steps taken to remedy the situation. Also the loss may be recovered, either through insurance or recovery of the stolen equipment. In the second, discovery is not likely to be made in time to prevent continued recurrence and the losses are gone forever.

Method of Planning and Control

What then, can you do to minimize your *operating losses?* The answer can be simply stated. Establish a *method* of planning and controlling each procedure in your entire organization from moving to a new location to completing the hole; from maintaining equipment at high operating efficiency to purchasing; obtaining new customers to financing; from figuring paychecks to writing them; in short, any procedure which *costs* you money.

Why a method? Would it not be as effective to examine procedures and plan changes as the mood struck you, or, as something came up so glaring that the situation needed immediate attention? I believe I can convince you that it would not. In the first place, examining procedures and planning changes cost money—money that you can visualize in your mind—so if done haphazardly, the tendency is to avoid those costs until a glaring situation comes up. In the meantime losses that are not so glaring are mounting —some day to become glaring situations.

In the second place, look around you at other drilling contractors and compare the competitive standing of those who use method in their administrative policies with that of those who do not. The contractor who uses up-to-date methods in the administration of his business is in a better competitive position on bidding for new jobs than one who does not.

Let's adopt a *method* of planning and control. Common sense tells us to make a preliminary examination as to the best place to apply such methods. Immediately we find we must know costs of alternative procedures, including indirect costs, in order to make decisions as to which to use. Knowledge of costs is absolutely necessary to effective planning of procedures, bidding on drilling contracts and then noting that effectiveness. Herein lies the subject of our article: That knowledge of costs is the watchman of our profits—both in the planning stage and in realization.

How do we obtain our cost data which we so loosely term "knowledge of costs"? We can do so by making cost estimates as the need arises without the use of formal records. We can institute, however, a set of formal records as part of our accounting system and call it "cost accounting." This up-to-date system is the most effective method of determining costs and the most accurate, although not completely accurate; some elements of costs in cost accounting are estimates (such as depreciation). Also some indirect costs may be distributed on an arbitrary basis. These factors, however, do not destroy the practical accuracy of the cost data in that depreciation is based on actual cost experience taken from past records and any arbitrary distribution is based on practical accuracy weighed against the cost.

Cost Accounting

What is cost accounting? In the oil well drilling business it is simply a system of double-entry bookkeeping that shows separately the cost elements of material, labor and overhead involved in the drilling of a particular well. This means that the cost elements mentioned must be separated on the books according to wells drilled—as well as to each other. The American Association of Oilwell Drilling Contractors manual on accounting for the drilling contractor covers this phase very well, giving a cost system that can be adapted to any size operation. This article will be restricted to some of the practical problems of cost determination and policies involved and some of the procedures used by Southeastern Drilling Company to save time and money on our cost records.

Cost accounting has been developed as a result of increasing competition in all lines of endeavor, increasing complexity of taxation, and the use of cost-plus contracts during the recent wars. One of its major uses is as a management tool in planning and control and is especially adaptable in larger businesses and in manufacturing. Numerous texts have been written on the subject for use in manufacturing and other industries. In the oil well drilling industry, however, texts are hard to find; the AAODC manual mentioned apparently being the leading one. This would indicate that the use of cost accounting by the drilling contractor is in a more or less embryonic state in comparison to other industries. This is borne out by the fact that the drilling industry is relatively young and the cost units (whether operating days or feet of hole) are so varying as to circumstances that it is difficult to develop costs from well to well that are comparative. A good many contractors, however, are continually improving their cost determining methods and at least one firm is now conducting an extensive investigation into cost accounting methods with the intent of completely revising its cost system with up-to-the-minute methods.

Statement of Operations

The end product of cost accounting at Southeastern is a monthly statement of drilling operations for the fiscal year to date of the statement. This statement shows the following for each well drilled during the period: Rig number; name of well; operating days; income (separated according to footage and day work, with total); cash expense: (Separated as to direct and overhead and totaled); Income before depreciation (or loss); Depreciation, and Net income (or loss).

The statement also shows the following for each well in progress at the end of the period: Rig number; name of well; operating days; cash expense (divided as to direct

*Partner and General Manager, Southeastern Drilling Company, Dallas, Texas.

expense or overhead, with a total), and depreciation.

The statement is arranged so that wells are grouped in rig order and a total for each factor of income is then developed for each rig.

What are some of the questions involved in the process of producing this statement? Since it is prepared directly from the books of account, probably the first would be whether to keep the books on a cash or accrual basis. Other questions involve depreciation policy, determination of the fiscal year, items to be charged direct to well cost or to overhead, chart of accounts, basis of overhead distribution to the wells, and, in order to make comparisons between wells and rigs, the selection of a unit (or units) to be used in developing comparable unit costs. All of these questions involve both the owner and the accountant and there should be a clear understanding between the two on all points.

The cash basis of accounting means the recording of income at the time of its receipt in cash, or its equivalent, and the recording of expenses at the time of payment therefor. The accrual basis means the recording of income when earned—even though not received—and the recording of expense when incurred—whether paid or not. Consideration must be given to the effect on income taxes as well as fiscal policy in determining which basis of accounting to use. Accrual basis accounting is more complicated and requires higher-paid personnel with more experience and know-how. At the end of any given period, however, all fiscal transactions of the period are on the books. This is highly important in financial and operating decisions. This may best be explained by setting forth an actual situation.

A company completed contracts amounting to $200,000 during a three months period in which $160,000 was received. Direct cost of these contracts was $165,000 of which $85,000 was paid during the period, overhead was $30,000 of which $25,000 was paid. Depreciation on rigs, drill pipe and other equipment was $25,000. A comparison of results of operation under the two bases of accounting follows:

JOHN DOE COMPANY
Net Drilling Income
Three Months Ended May 31, 1955

	Accrual basis	Cash basis
Drilling income	$200,000	$160,000
Expenses:		
Direct	165,000	85,000
Overhead	30,000	25,000
Depreciation	25,000	25,000
Total expenses	220,000	135,000
Net income or (loss)	(20,000)	25,000

The accrual basis presents a reasonably complete picture whereas, on the cash basis, the operator has to supply the missing figures from scratch sheets, memory or guess. The cash basis set of figures is further complicated by the normal receipt or payment of cash during the period on account of operations of prior periods. Such complication has not been illustrated in the above example. The small operator who carries his figures in his hip pocket or in his head may satisfactorily employ a cash basis for accounting. As his operations expand, however, he has less and less time to devote to figures. He should then change to the accrual basis which supplies the complete figures for him. The time of such a change depends to a certain extent on individual needs and policies but should take place before a period of rapid expansion or as soon as the business can stand the added cost in case of normal expansion.

Income-tax-wise, the cash basis is flexible to some extent in contrast to the rather inflexible accrual basis. As the business grows the cash basis advantage of flexibility is minimized. No attempt will be made here to set forth specific income tax advantages, or disadvantages, of one basis in comparison with another. You should see your income tax consultant with regard to this matter. It is well to remember, however, that permission to change from one basis to the other must be obtained from the Internal Revenue Service.

Southeastern started in business on the cash basis but soon changed to the accrual basis which it now uses.

Unit of Cost

Of importance in oil well cost accounting is the selection of a cost unit on which relatively comparable costs may be obtained. In the oil producing industry this unit of cost is the barrel of oil. For coal, it is ton of ore. However, we in the drilling industry are rendering a service which is difficult to measure in terms of weight, volume, or quality that is subject to accepted standards. Each foot of hole that is drilled varies due to type of formation encountered, conditions that may be imposed by the customer, and changes in total depth of the hole. Therefore costs developed per foot of hole would not be useful from one well to the next.

It seems that the uniform time unit of cost is the most comparable and is the unit recommended by AAODC in its manual.

Other cost units may be adopted within the basic unit. For example, Southeastern men in the field with company cars are required to report the speedometer reading at the end of each month on their expense reports. The cost to operate each car is accumulated on our books and it is a simple matter to obtain the unit cost per mile to operate. This information is used effectively, too. Several years ago we found we could operate rental cars as cheaply as owned cars, thereby releasing funds tied up in owned cars for other purposes. Now the situation has changed and we find it is cheaper to own our cars. The decision to change back to owned cars was influenced to a large degree by information contained in the cost records. Another effective use of such information is the comparison of unit costs between different makes and models and the control of abnormal costs as to drivers.

All items and categories of unit costs should be compared periodically for control and planning purposes, as in the example just related. Cost trends are noted so that timely and suitable action can then be taken where necessary. These periodic comparisons should be made monthly or quarterly in the case of major categories, the larger the operation the more frequent. In the case of individual items the particular situation should govern, but no item should go longer than semi-annually without examination.

It is feasible in the case of large operations to make cost comparisons directly on the records. Exceptions to standards and unfavorable trends are noted as they develop. A study is made of any particular situation and an oral or written report as to the reasons therefor and recommended means of correction is made to the owner or management.

Depreciation

Depreciation is another practical problem to be answered before the cost of drilling can be determined. Accounting-wise, it is the recovery of the cost of a piece of equipment through periodic charges to income. The cost to be recovered is the difference between the purchase price and estimated salvage value at the time it becomes necessary to replace the equipment. The cost to be recovered or "depreciable sum" is then spread over the estimated productive life. The productive life is estimated in terms of cost units which may be rig operating days, in the case of a rig, or feet of hole drilled, in the case of drill pipe, or calendar years, in the case of automobiles. There are several methods of spreading the depreciable sum over the estimated life of the equipment, the straight-line method being the one most widely used. The 1954 Internal

Revenue Code permits the percentage of declining balance method and the sum-of-the-years digit method beginning with new equipment acquired since December 31, 1953.

The straight-line method means that each cost unit bears the same cost throughout the life of the equipment; whereas, in the other two methods the earlier costs units bear a heavier proportion of costs than the later cost units. An example of depreciation under the three methods follows. A rig which cost $300,000 has an estimated salvage value of 15% of cost or $45,000 and an estimated productive life of 2,200 rig operating days (8 years at 275 rig operating days per year).

DEPRECIATION SUSTAINED

Each 275 rig operating day period	Method: Straight line	Per cent of reducing balance	Sum-of-the-years digits
1st	$ 31,875	$ 75,000	$ 56,667
2nd	31,875	56,250	49,583
3rd	31,875	42,188	42,500
4th	31,875	31,640	35,417
5th	31,875	23,730	28,333
6th	31,875	17,798	21,250
7th	31,875	13,348	14,167
8th	31,875	10,011	7,083
	255,000	269,965	255,000
Per rig operating day during each 275 day period			
1st	$116	$273	$206
2nd	116	204	180
3rd	116	153	154
4th	116	115	128
5th	116	86	103
6th	116	65	77
7th	116	49	51
8th	116	36	26

The above depreciation methods are fully described in almost any tax handbook. It can readily be seen that the two latter methods have certain income tax advantages over the straight-line method in the early years of life. This is offset by the disadvantage of lighter charges in the later years.

As was stated earlier, depreciation is an estimate. Actually, a systematic program of maintenance and repairs may result in a longer life than estimated. This means then that the net profit for a given period is greater than that shown on the books. This point should always be considered when examining and analyzing operating statements. Likewise, a poor maintenance program might mean the book profits are overstated due to insufficient depreciation being charged. Business prudence suggests that it is better to understate profits than overstate them and for this reason most operators depreciate their rigs as fast as possible.

There are two factors limiting excessive depreciation. One is the development of reasonable costs for competitive bidding. The other is limitation on excessive rates by the Internal Revenue Service. In setting up your rates (based on estimated life and method) you should carefully consider these factors. It is also well to bear in mind that the Internal Revenue Service requires consistency in your rates and will not permit a change in method (except in one instance) without its consent. Also, it is wise to follow a policy of consistency for cost comparisons and cost estimates.

There is one other thing before leaving the subject of depreciation. We depreciate our rigs on a rig operating day basis rather than on a calendar day basis. This keeps depreciation comparable from well to well and avoids the problem of depreciation charges while the rig is down.

Overhead

Overhead represents all costs of operating the business not charged directly to wells or recovered through depreciation. It includes salaries, transportation, communication and travel expense of administrative and certain field supervisory personnel, office and accounting expense, legal expense, public relations, advertising, general taxes and insurance, club and trade association dues, interest, etc. Overhead is accumulated and distributed to wells on a basis of rig operating days which is the cost unit previously recommended for well costs.

Two very informative calculations can be made in connection with overhead. These are based on the fact that overhead remains relatively fixed within certain limits as to number of rigs operating. One is the calculation of the breakeven point. The other is estimating a reduced overhead cost factor to see if additional rigs would result in an improved competitive position cost-wise.

As an example of the calculation of the breakeven point, let's say that a drilling company owns 7 rigs and at 75% busy (which is its normal rate of business) it earns a net income of 10% of drilling income. Its monthly overhead is $30,000 per month, and average income earned per operating day is $1100.

Operating days (30) (7) (.75)	157
Drilling Income (157) (1100)	172,700
Net income 10% thereof	17,270
Overhead	30,000
Costs other than overhead	125,430

This means costs other than overhead amount to approximately $800 per day. The breakeven point is then arrived at in this manner.

Income per day	$1100
Cost other than overhead per day	800
Available for overhead	$ 300 daily

Number of operating days required to breakeven

$$\frac{30{,}000}{300} = 100$$

% Busy

$$\frac{100}{210} = 47.6\%$$

How will the addition of more rigs serve to reduce the overhead factor? Using the same set of figures in the preceding example, we compute the overhead factor to be $191 per operating day ($30,000 overhead per month divided by the normal operating days 157). It is estimated that the addition of two more rigs would increase the monthly overhead to $32,000. Nine rigs operating at 75% busy results in 202 operating days per month. The resulting estimated overhead cost factor would be $158 per operating day, a reduction of $33 per day.

There are two items mentioned at the beginning of our discussion which have not been discussed. One is the chart of accounts. On it is listed all the accounts used in recording the financial and operating transactions of the business. Terminology used in naming and describing the accounts is a key to clear understanding between the owners and the accountant. Consequently, it is important that the chart of accounts be discussed with and fully approved by management even though prepared by the accountant. The order of accounts in the financial and operating statements in the books of account and on the chart of accounts should be the same in accordance with good accounting practice. The AAODC manual is recommended as a guide in organizing your accounts.

The question of what fiscal year to use is often limited by income tax considerations. It is well to see a tax consultant before deciding on a fiscal year.

Cost reports and analyses are not an end in themselves but are management tools. As with any tool they must be used to be effective. Train yourself in their use and then use them. You will be glad you did.

Shell's first

Permanent Platform

now working

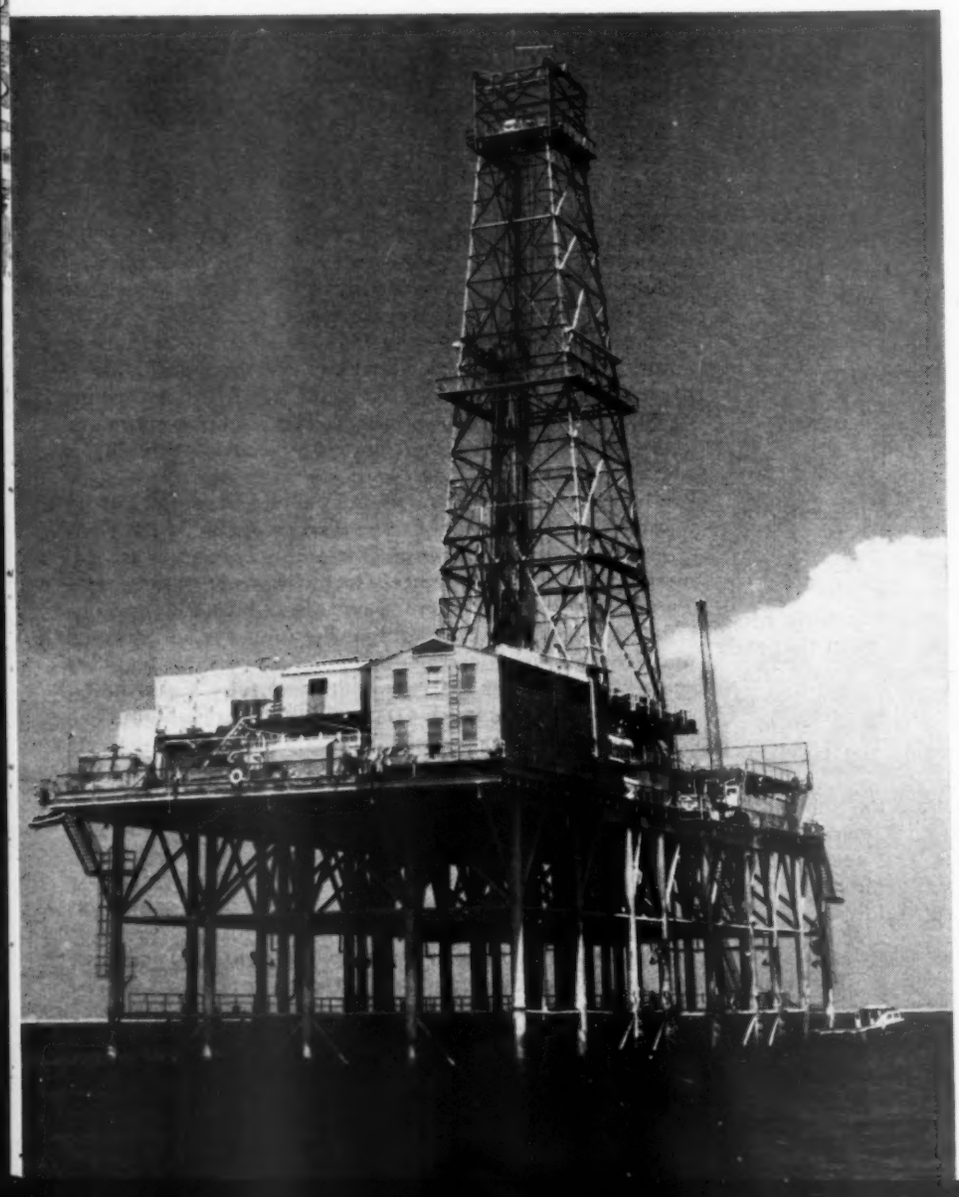
THE first permanent, self-contained drilling platform built off the coast of Louisiana by Shell Oil Company is now sinking a wildcat well in 72 ft of water in East Bay, Block 42, near the mouth of the Mississippi River.

The huge structure is 197 ft long and 82 ft wide. The distance from the bottom of its steel piles to the top of its derrick is 650 ft, equivalent to the height of a 50-story building.

The platform is capable of drilling 12 directional wells. Upon their completion, it can be turned into a giant production platform by removing the drilling equipment.

Its cost of more than $1,250,000, plus the price of $2,250,000 Shell paid the state of Louisiana for the lease, plus the expense of drilling, represents a total of more than $4,250,000 risked on the chance of finding oil at this particular spot.

An unusual type of derrick rests on Shell Oil Company's first permanent platform, now drilling its first wildcat in Block 42 near the mouth of the Mississippi River. Both rotary table and crown block can be moved within the derrick, and the derrick can be skidded so that a total of 12 directional wells can be drilled off this single platform.



Shell engineers decided a permanent-type platform was the only practical means of drilling in the deep water and very soft, muddy sea-bottom found in Block 42. The 53 steel piles on which it stands are 460 ft long. They sank 200 ft below the ocean floor before striking a "reaction" or resistive earth stratum and extend to a total depth of 370 ft into the mud. Main deck of the platform is 45 ft above mean water level. The derrick towers another 160 ft above the deck.

The platform and derrick are designed to withstand the buffeting of 50-ft waves and 125-mph winds.

An unusual feature of the platform is its movable superstructure, which allows 12 wells to be drilled from the one location. Below the drilling deck and about 10 ft above the water is a short, steel deck having two rows of three "water-table openings." Through these openings, 500 ft of 30-in. drive pipe are sunk to keep out the sea water. The drill bit, drill stem, and casing pass through these drive pipes.

Both the crown block at the top of the derrick and the rotary table on the 40 by 45-ft drilling deck can be shifted to a position over each of the water table openings. To drill six additional wells the entire drilling deck, derrick, drawworks, engines, pipe racks, and generators can be skidded some 22 ft along the platform.

The crew quarters have sleeping, galley, mess hall, and recreation space for 30 men. Radio provides constant contact with Shell offices and the various craft serving the rig.

Three 450-hp diesel engines power the drawworks and three 75-kw unit generators run the lights and air conditioning in the crew quarters. The racks hold 2100 tons of pipe. Tanks can store 2500 bbl of fresh water, 750 bbl of active mud and 1000 bbl of reserve mud. The rig also has space for 4000 sacks of dry mud and 1400 sacks of dry cement. * * *

XUM

Rocky Mountain Region Under Wide Exploration

The Tennessee Transmission Company has laid the groundwork for more extensive oil and gas production operations in the Rocky Mountain region of the United States and in Western Canada by creation of a Rock Mountain Production Division, R. C. Graham, senior vice president, announced.

The new division and intensified activity in the two areas are created by the purchase of the Far West Oil Company in Wyoming, and the recent acquisition of oil and gas properties formerly owned by the Bay Petroleum Corporation of Denver and the personal producing properties of C. U. Bay, former president of Bay Petroleum.

Headquarters for the new division have been set up in Denver, with production district offices in Casper, Wyoming; Chase, Kansas; Oklahoma City, and in Edmonton, Canada.

H. I. Craig, an employee of Bay Petroleum since 1940, heads the division as division production superintendent.

Others include H. E. Rowe, Jr., division engineer, also a former employee of Bay Petroleum, and Sam F. Willson, Jr., the division production clerk, who has been with Tennessee Gas for a number of years.

District production superintendents, all formerly with Bay Petroleum are as follows: Casper, Wyoming, Patterson Lay; Chase, Kansas, Glen E. Armour; Edmonton J. A. Leask, and, Oklahoma City, J. D. Hicks.

SEPM Meeting Set Oct. 12

The Gulf Coast Association of Geological Societies is holding its fifth annual meeting October 12 through 14 in Biloxi, Mississippi. The Mississippi Geological Society will be host group and the Baton Rouge and Southeastern Geological Societies are assisting with plans for the meeting.

Members of the Gulf Coast Section of the SEPM have been invited to take part in the meeting. Technical sessions will be held in the Hurricane Room of the Buena Vista Hotel in Biloxi.

Technical programs are planned for Thursday, October 13, and Friday, October 14.

Robert D. Sprague of Jackson, Mississippi, is general chairman for the meeting. Other committee chairmen are: A. E. Blanton, program; Claude Smith, entertainment; Gerald K. Anderson, project equipment; W. J. Nugent, housing; X. M. Frascogna, advertising; Les Reynolds, publicity; R. L. Morris, registration; E. L. Russell, geological exhibits; and Robert E. Shaver, SEPM program.

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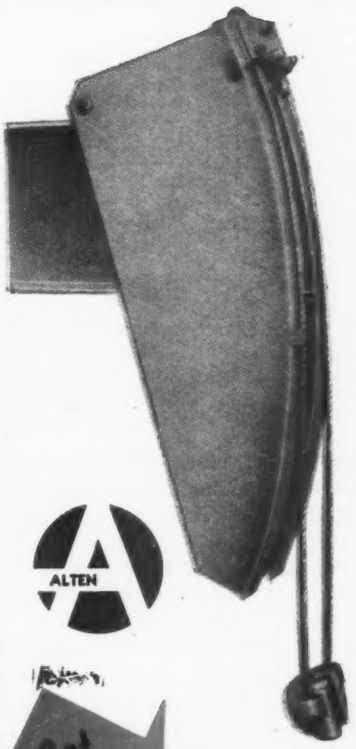

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DRILLING FEATURE

THE PETROLEUM ENGINEER'S CONTINUOUS TABLES

Slim Hole Drilling Tables

Contents

Velocity of Mud in Annulus . . . . . Table 1

Selection of Bit Nozzle Size . . . . . Table 2

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Drawworks Input Horsepower . . . . . Table 8

THESE tables have been prepared for the assistance of those engaged in or considering slim hole drilling operations. For simplification, data are based upon typical mud properties. Values contained in the tables should be used as approximations only. Normally, due to the wide variation of conditions in drilling, these values will be sufficiently accurate for most uses. Where more accurate results are required, calculations should be made using actual mud properties and universal friction graphs for the flow of fluids in pipes.

Annular Velocity. In drilling operations, annular velocities range from 100 to 180 ft per min. Circulation rates required to produce a given annular velocity may be selected from Table 1. In areas where considerable hole enlargement is anticipated, the circulation rate is normally increased proportionately or selection of rate is based on the next larger hole size.

Bit Nozzle Size. Jet nozzle velocities and water course velocities for conventional bits are provided in Table 2 and are designed for use in selecting nozzle sizes for jet bits.

Circulating Pressure. Pressure losses for the drilling string components are provided in Tables 3, 4, and 5. Both internal and external pressure losses are contained in the values shown and are based upon a 10 lb per gal mud. Total pressure drops obtained from these tables should be corrected 10 per cent for each pound of mud weight over the 10 lb/gal weight. With the low circulation rates used in slim hole work, the pressure loss in surface connections is normally small and is neglected here. Where the resistance of the surface connection is known, value may be added to the total pressure loss.

(Example, using Tables 3, 4, and 5)

Determine the circulating pressure in drilling a 4¾ in. hole to 6000 ft with a circulation rate of 130 gpm. Drilling string consists of 5600 ft 2⅜-in. DP with IF tool joints, 400 ft of 3½ by 1¾ drill collars, and a two cone jet bit with 5/16-in. nozzles.

	Pressure Drop
Surface Connections	negligible
Loss for drillstem (Table 3) 56 × 36.7	2055 psi
Loss for drill collars (Table 4) 4 × 45.2	181
Loss thru jet bit (5/16-in. nozzles) Table 5	705
Total	2941 psi
Correction for mud weight (2931 × 1.1)	3224
Circulation pressure	3224 psi

To calculate pressure losses for pipe and hole sizes not shown in these tables, you are referred to equations shown in Table 6.

Pump Input Horsepower. Two values are included in Table 7 for ease in calculating pump horsepower requirements. Where pump horsepower accuracy to the nearest 500 psi discharge pressure is satisfactory, tabular values from 500 to 7500 psi are included. For greater accuracy multiply the horsepower per lb of pressure shown in Table 7 by the calculated circulation pressure. Values of pump horsepower were calculated from the following

$$\text{Pump Input Horsepower} = \frac{\text{Circulation Rate, GPM} \times \text{Pressure}}{1714 \times .765}$$

Where .765 is the assumed volumetric and mechanical efficiency of the pump.

Drawworks Input Horsepower. It is common practice to based the drawworks horsepower requirement on that power required to raise the drilling string off bottom at the rate of 100 ft per minute. Two values are provided in Table 8, hook horsepower and drawworks input horsepower. Hook horsepower is the power required at the elevators to move the string at this rate. Drawworks input horsepower is the power input to the drawworks required to raise the drill string at this rate, based on a mechanical efficiency of 66 per cent, which takes into consideration drawworks, crown block, and travelling block losses.

Example

In the previous example, a 6000-ft drilling string consisted of 2⅜-in. DP with IF tool joints and 400 ft of 3½-in. by 1¾-in. drill collars. The hook horsepower is calculated as follows:

Power for drill pipe 56 × 2.23	125
Horsepower required by drill collars, 4 × 7.42	30
Total hook horsepower	155

Calculated in the same manner as above, the drawworks input horsepower is up 234 hp.

Correction for Mud Weight

Tables 3, 4, and 5 are based upon a mud weight of 10 lb per gallon. The pressure loss in the mud system is proportional to the weight of the mud in use. In light of this, values of pressure loss obtained using the tables must be corrected for weight of mud used.

Multiply the Total Pressure Loss in System by the Following Factors:

Mud Weight lb/gal	Correction Factor
11	1.1
12	1.2
13	1.3
14	1.4
15	1.5
16	1.6

TABLE 1. Velocity of mud in annulus. Velocities in ft/min.

Hole Size (in.)	Pipe OD (in.)	Circulation Rate GPM																
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
3⅞	2⅜	157	183	209	236	262	288	314	—	—	—	—	—	—	—	—	—	—
4¼	2⅜	119	138	158	178	198	218	237	257	276	296	316	—	—	—	—	—	—
4¾	2⅜	87	102	116	131	145	159	174	188	203	217	232	246	261	276	290	304	—
	2⅞	103	120	137	154	172	189	206	223	240	258	275	292	309	—	—	—	—
5⅝	2⅜	—	—	76	85	94	104	113	123	132	142	151	160	170	179	189	198	217
	2⅞	—	73	84	95	105	115	126	136	147	157	168	178	188	199	210	220	231
	3½	76	89	101	114	127	139	152	165	177	190	202	215	228	240	254	266	279
6	2⅜	—	—	—	73	81	89	97	105	113	121	130	138	146	154	162	170	178
	2⅞	—	—	71	80	88	97	106	115	124	133	142	150	159	168	177	185	194
	3½	—	72	83	93	103	114	124	134	145	155	165	176	196	206	206	217	227
6⅛	2⅞	—	—	—	76	84	92	101	109	117	126	134	143	151	159	168	176	184
	3½	—	—	78	87	97	107	117	126	136	146	155	165	175	184	194	204	214
6¼	2⅞	—	—	—	72	80	88	96	103	111	119	127	135	143	151	159	168	176
	3½	—	—	73	82	92	101	110	119	128	137	146	156	165	174	183	193	202

TABLE 2. Selection of bit nozzle size. Jet velocities in ft/sec.

Circulation Rate GPM	Three Cone Jet Bit (nozzle size)						Three Cone Bit (3-drilled water course)			Two Cone Jet Bit (nozzle size)							Two Cone Bit (2-drilled water course)		
	1/4"	5/16"	3/8"	13/32"	7/16"	1/2"	5/8"	11/16"	3/4"	1/4"	5/16"	3/8"	13/32"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"
60	131	—	—	—	—	—	—	—	—	196	125	—	—	—	—	—	31	26	—
70	152	—	—	—	—	—	—	—	—	228	146	101	—	—	—	—	37	30	25
80	174	112	—	—	—	—	28	—	—	260	167	116	—	—	—	—	42	35	29
90	196	125	—	—	—	—	31	26	—	293	188	130	111	—	—	—	47	39	33
100	218	139	—	—	—	—	35	29	—	326	209	145	124	107	—	—	52	43	36
110	239	153	106	—	—	—	38	32	27	358	230	159	136	117	—	—	57	47	40
120	261	167	116	—	—	—	42	35	29	391	251	174	148	128	—	—	63	52	43
130	282	181	126	107	—	—	45	37	31	424	272	188	161	139	106	—	68	56	47
140	304	195	135	115	100	—	49	40	34	456	292	202	173	150	114	—	73	60	51
150	326	209	145	124	107	—	52	43	36	489	314	217	185	160	122	—	78	65	54
160	348	223	155	132	114	—	56	46	39	521	334	232	198	171	130	—	83	69	58
170	376	237	164	140	121	—	59	49	41	—	355	246	210	182	138	110	89	73	62
180	391	251	174	148	128	—	63	52	44	—	377	260	222	192	147	116	94	78	65
190	413	265	184	157	135	—	66	55	46	—	397	275	235	203	155	122	99	82	69
200	435	279	193	165	142	109	70	58	48	—	418	290	247	214	163	129	104	86	72
210	457	291	203	172	150	—	73	61	50	—	440	304	259	224	171	135	109	90	75
220	479	305	213	180	157	—	77	64	53	—	460	319	272	235	179	142	114	94	79

TABLE 3. Pressure loss for drillstem (psi per 100 ft).
Includes both external and internal losses.

Hole Size	Drill Pipe and Tool Joint	Circulation Rate GPM																
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
3⅞"	2⅜" Tbg—I.F.	7.1	9.7	12.4	15.7	19.1	16.3	27.1	31.5	—	—	—	—	—	—	—	—	—
	2⅜" D P.—Reg. API	17.6	23.8	30.6	38.5	46.7	55.8	65.8	76.3	—	—	—	—	—	—	—	—	—
	2⅜" D.P.—S.H.	11.7	15.8	20.3	25.6	31.1	37.2	43.8	50.8	—	—	—	—	—	—	—	—	—
	2⅜" D.P.—I.F.	13.4	18.1	23.4	29.5	36.0	43.1	51.0	59.3	—	—	—	—	—	—	—	—	—
4¼"	2⅜" Tbg—I.F.	5.5	7.4	9.5	12.0	14.5	17.4	20.5	23.7	27.4	31.1	35.6	39.5	—	—	—	—	—
	2⅜" D.P.—Reg. API	15.7	21.2	27.1	34.2	41.3	49.2	58.0	67.2	77.4	87.9	100.5	111.0	—	—	—	—	—
	2⅜" D.P.—S.H.	10.2	13.8	17.6	22.2	26.9	32.1	37.8	43.8	50.5	53.3	65.5	72.3	—	—	—	—	—
	2⅜" D.P.—I.F.	9.5	12.9	16.5	20.9	25.3	30.1	35.1	41.2	47.6	54.0	61.7	68.4	—	—	—	—	—
4¾"	2⅜" Tbg—I.F.	4.8	6.4	8.2	10.4	12.6	15.0	17.6	20.4	23.6	26.7	30.6	33.8	38.1	41.6	46.0	50.6	—
	2⅜" D.P —Reg. API	14.9	20.2	25.8	32.5	39.2	46.7	55.0	63.7	73.3	83.2	95.2	104.9	118.4	129.0	142.6	156.7	—
	2⅜" D.P.—S.H.	9.5	12.9	16.4	20.7	25.0	29.8	35.1	40.6	46.8	53.1	60.7	67.0	75 6	82.4	91.0	100.1	—
	2⅜" D.P.—I.F.	8.6	11.6	14.8	18.7	22.6	26.9	31.7	36.7	42.3	47.9	54.8	60.6	68.2	74.3	82.2	90.3	—
	2⅞" Tbg—I.F.	2.5	3.4	4.4	5.5	6.7	8.0	9.5	11.1	12.7	14.5	16.5	18.4	20.7	22.8	—	—	—
	2⅞" D.P.—Reg. API	6.6	8.8	11.4	14.3	17.5	20.8	24.1	28.3	32.6	37.1	42.1	46.9	52.6	58.0	—	—	—
	2⅞" D.P.—Hydril I.F.	4.2	5.6	7.2	9.0	11.0	13.2	15.5	18.1	20.8	23.7	26.8	30.2	33.6	37.2	—	—	—
5⅝"	2⅜" D.P.—Reg. API	—	19.7	25.1	31.7	38.3	45.5	53.6	62.0	71.4	81.0	92.7	102.1	115.2	125.5	138.7	152.4	173.5
	2⅜" D.P.—S.H.	—	12.4	15.8	20.0	24.1	28.7	33.8	39.1	45.0	50.9	58.4	64.3	72.7	79.1	87.4	96.0	112.0
	2⅜" D.P.—I.F.	—	11.0	14.1	17.8	21.5	25.6	30.1	34.8	40.1	45.5	52.0	57.4	64.7	70.5	77.9	85.7	93.5
	2⅞" Tbg—I.F.	1.8	2.5	3.2	4.0	4.8	5.7	6.8	7.8	9.0	10.2	11.7	13.0	14.6	15.9	17.5	19.6	21.5
	2⅞" D.P.—Reg. API	5.8	7.7	9.9	12.4	15.2	18.0	20.8	24.4	28.0	31.9	36.2	40.4	45.2	49.7	54.7	60.3	66.1
	2⅞" D.P.—S.H.	3.3	4.7	6.1	7.6	9.2	11.0	13.0	15.1	17.3	19.8	22.3	25.0	27.8	30.7	33.7	37.0	40.3
	2⅞" D.P.—Hydril I.F.	3.0	4.3	5.5	6.9	8.5	10.1	11.9	13.8	15.8	18.0	20.3	22.9	25.4	28.0	30.9	33.6	36.6
	3½" Tbg—S.H.	1.2	1.6	2.1	2.6	3.2	3.8	4.5	5.2	6.0	6.8	7.8	8.7	9.8	10.7	11.9	13.1	14.3
	3½" D.P.—Reg. API	2.4	3.2	4.2	5.2	6.4	7.6	8.9	10.4	12.0	13.6	15.5	17.2	19.4	21.2	23.4	25.8	28.3
	3½" D.P.—S.H.	1.4	1.9	2.5	3.2	3.9	4.6	5.4	6.3	7.3	8.3	9.4	10.5	11.8	13.0	14.3	15.5	16.8
	3½" D.P.—I.F.	1.5	2.0	2.5	3.2	3.9	4.8	5.5	6.5	7.5	8.5	9.7	10.9	12.1	13.4	14.9	16.3	17.8
6"	2⅞" Tbg—I.F.	—	2.3	3.0	3.8	4.6	5.5	6.4	7.4	8.5	9.6	11.1	12.3	13.8	15.1	16.6	18.2	19.9
	2⅞" D.P.—Reg. API	—	7.6	9.8	12.3	15.0	17.8	20.6	24 1	27.8	31.6	35.8	39.9	44.7	49.1	54.1	59.1	64.5
	2⅞" D.P.—S H.	—	4.6	5.9	7.4	9.0	10.7	12.6	14.7	16.8	19.2	21.7	24.3	27.0	29.8	32.8	35.9	39.2
	2⅞" D.P.—Hydril I.F.	—	4.2	5.3	6.7	8.2	9.8	11.5	13.4	15.3	17.4	19.6	22.1	24.5	27.0	29.8	32.6	35.6
	3½" Tbg—S.H.	—	1.4	1.8	2.2	2.7	3.2	3.7	4.4	5.0	5.7	6.5	7.2	8.1	8.9	9.8	10.8	11.8
	3½" D.P.—Reg. API	—	3.0	3.8	4.8	5.8	6.9	8.1	9.4	10.9	12.3	14.1	15.6	17.5	19.2	21.2	23.2	25.4
	3½" D.P.—Acme.	—	2.0	2.5	3.2	3.8	4.6	5.4	6.2	7.2	8.2	9.3	10.3	11.6	12.7	14.1	15.5	16.9
	3½" D.P.—I.F.	—	1.6	2.0	2.5	3.1	3.7	4.3	5.1	5.8	6.6	7.6	8.4	9.4	10.4	11.5	12.6	13.8
6⅛"	2⅞" Tbg—I.F.	—	—	3.0	3.8	4.6	5.4	6.4	7.4	8.5	9.6	11.0	12.2	13.7	14.9	16.5	18.1	19.8
	2⅞" D.P.—Reg. API	—	—	9.8	12.3	14.9	17.7	20.5	24.1	27 7	31.5	35.7	39.8	44.5	48.9	53.8	58.9	64.5
	2⅞" D.P.—S.H.	—	—	5.9	7.4	8.9	10.7	12.6	14.6	16.7	19.1	21.5	24.1	26.8	29.7	32.6	35.7	39.1
	2⅞" D.P.—Hydril I.F.	—	—	5.2	6.8	8.1	9.7	11.4	13.3	15.2	17.3	19.5	21.9	24.3	26.8	29.6	32.4	35.5
	3½" Tbg—S.H.	1.1	1.4	1 9	2.3	2.8	3.4	4.0	4.7	5.4	6.1	7.0	7.8	8.7	9.6	10.6	11.6	12.7
	3½" D.P.—Reg. API	—	3.2	3.9	4.9	6.0	7.1	8.4	9.7	11.2	12.7	14.5	16.1	18.1	19.8	21.9	24.0	26.3
	3½" D.P.—Acme.	—	2.0	2.6	3.3	4.0	4.8	5.6	6.5	7.5	8.6	9.8	10.8	12.2	13.4	14.8	16.2	17.7
	3½" D.P.—I.F.	—	1.5	1.9	2.4	2.9	3.6	4.1	4.9	5.5	6.3	7.2	8.0	8.9	9.8	10.9	12.0	13.0

XUM

TABLE 3 (Continued). Pressure loss for drillstem (psi per 100 ft).

Hole Size	Drill Pipe and Tool Joint	Circulation Rate GPM																
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
6¼"	2⅞" Tbg—I.F.	—	—	3.0	3.7	4.5	5.3	6.3	7.3	8.4	9.4	10.8	12.0	13.5	14.7	16.2	17.7	19.4
	2⅞" D.P.—Reg. API	—	—	9.8	12.2	14.9	17.6	20.4	24.0	27.6	31.4	35.5	39.6	44.3	48.7	53.7	58.7	64.3
	2⅞" D.P.—S.H.	—	—	—	5.9	7.3	8.9	10.6	12.5	14.6	16.6	19.0	21.4	24.0	26.7	29.5	32.4	35.4	38.8
	2⅞" D.P.—I.F.	—	—	—	5.3	6.6	8.1	9.7	11.3	13.2	15.1	17.2	19.4	21.8	24.2	26.7	29.4	32.2	35.2
	3½" Tbg—S.H.	—	1.3	1.6	2.0	2.5	2.9	3.4	4.0	4.6	5.3	6.0	6.7	7.5	8.2	9.1	10.0	10.9
	3½" D.P.—Reg. API	—	2.9	3.7	4.6	5.6	6.7	7.8	9.1	10.5	11.9	13.6	15.0	16.9	18.4	20.4	22.3	24.5
	3½" D.P.—Acme.	—	1.9	2.4	3.0	3.6	4.3	5.1	5.9	6.8	7.7	8.8	9.8	11.0	12.0	13.3	14.6	15.9
	3½" D.P.—I.F.	—	1.2	1.8	2.3	2.8	3.4	3.9	4.7	5.3	6.1	6.9	7.7	8.6	9.5	10.5	11.5	12.6

Drill Pipe Contained in Tables

2⅜" Tbg —2⅜" OD 4.7# EUE Tubing
2⅜" D.P.—2⅜" OD 6.65# D.P.
2⅞" Tbg —2⅞" OD 6.5# EUE Tubing
2⅞" D.P.—2⅞" OD 10.40# D.P.
3½" Tbg —3½" OD 9.3# EUE Tubing
3½" D.P.—3½" OD 13.3# D.P.

TABLE 4. Pressure loss due to drill collars (psi per 100 ft).

Hole Size	Drill Collar OD x ID	GPM																
		60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
4¾"	3¾ x 1¾	12.3	16.6	21.4	27.0	32.9	39.2	46.4	54.0	62.4	71.0	81.1	90.2	101.6	111.5	123.4	135.8	148.3
	3½ x 1¾	10.3	14.0	18.0	22.8	27.6	33.0	38.9	45.2	52.1	59.2	67.6	75.0	84.4	9.25	102.4	112.6	123.0
5⅝"	3¾ x 1¾	8.6	11.6	14.8	18.7	22.6	26.9	31.6	36.7	42.3	48.0	54.8	60.5	68.3	74.5	82.4	90.6	98.7
	4⅛ x 1¾	9.0	12.2	15.6	19.7	23.8	28.4	33.4	38.7	44.7	50.7	57.9	64.0	72.2	78.8	87.2	95.9	104.6
6"	3¾ x 1¾	8.3	11.2	14.4	18.2	21.9	26.1	30.6	35.5	41.0	46.4	53.0	58.5	66.1	72.0	79.6	87.5	95.4
	4⅛ x 1¾	8.5	11.5	14.7	18.5	22.4	26.6	31.3	36.3	41.9	47.5	54.3	59.9	67.6	73.7	81.5	89.6	97.
	4¾ x 2¼	3.8	5.1	6.5	8.3	10.1	12.0	14.2	16.5	19.2	21.8	24.9	27.7	31.1	34.2	37.8	41.7	45.5
6⅛"	3¾ x 1¾	8.3	11.2	14.3	18.0	21.8	25.9	30.5	35.3	40.7	46.1	52.7	58.1	65.6	71.5	79.0	86.9	94.7
	4⅛ x 1¾	8.4	11.3	14.5	18.3	22.1	26.3	31.0	35.9	41.4	46.9	53.6	59.2	66.8	72.8	80.5	88.5	96.5
	4¾ x 2¼	3.4	4.6	5.9	7.4	9.0	10.8	12.8	14.8	17.1	19.5	22.3	24.8	27.8	30.6	33.8	37.3	40.7
6¼"	4⅛ x 1¾	8.3	11.3	14.4	18.2	21.9	26.1	30.7	35.6	41.0	46.5	53.1	58.6	66.2	72.1	79.7	87.7	95.6
	4¾ x 2¼	3.1	4.3	5.4	6.9	8.4	10.0	11.8	13.7	15.8	18.0	20.5	22.8	25.6	28.1	31.0	33.2	37.5
	5¼ x 2	6.6	8.9	11.5	14.5	17.7	21.2	25.0	29.1	33.7	38.3	43.8	48.7	54.8	60.2	66.6	73.3	80.2

TABLE 5. Pressure drop across bit (psi).

Circulation Rate GPM	Three Cone Jet Bit (three nozzles)						Two Cone Jet Bit (two nozzles)							Three Cone Conventional Bit (3 drilled water courses)			Two Cone Conventional Bit (2 drilled water courses)			
	1/4"	5/16"	3/8"	13/32"	7/16"	1/2"	1/4"	5/16"	3/8"	13/32"	7/16"	1/2"	5/8"	1/2"	5/8"	11/16"	1/2"	5/8"	11/16"	3/4"
60	154	—	—	—	—	—	346	140	—	—	—	—	—	—	—	—	—	—	—	—
70	209	—	—	—	—	—	470	190	93	—	—	—	—	—	—	—	—	—	—	—
80	273	111	—	—	—	—	614	250	121	—	—	—	—	—	—	—	—	—	—	—
90	346	140	—	—	—	—	779	315	154	110	—	—	—	—	—	—	69	—	—	—
100	427	173	—	—	—	—	960	389	190	136	102	—	—	—	—	—	85	—	—	—
110	518	209	102	—	—	—	1160	470	227	165	124	—	—	—	—	—	103	—	—	—
120	615	249	122	—	—	—	1380	560	274	198	147	—	—	55	—	—	122	50	—	—
130	721	282	143	102	—	—	1620	705	321	228	173	102	—	64	—	—	143	58	—	—
140	838	339	166	119	—	—	1880	762	373	268	200	116	—	73	—	—	163	68	46	—
150	961	389	190	136	102	—	2160	875	427	307	228	135	—	85	—	—	190	77	53	—
160	1095	443	216	155	116	—	2460	995	486	349	262	154	—	97	—	—	216	88	60	—
170	1236	500	244	175	132	—	2770	1124	549	394	296	173	—	109	45	—	245	99	68	—
180	1380	560	273	196	148	—	3100	1258	614	441	332	195	—	122	50	—	274	111	76	54
190	1540	625	305	219	164	—	—	1405	685	493	369	217	—	136	55	—	305	124	85	60
200	1710	691	338	242	182	—	—	1552	760	546	410	241	—	151	62	—	340	138	95	67
210	1890	762	373	267	200	—	—	1710	840	601	452	266	—	167	68	47	375	152	105	74
220	2070	836	409	293	220	—	—	1880	920	656	496	292	—	183	75	51	412	167	115	81

TABLE 6. Equations for pressure loss calculations.

FRICTION LOSSES THROUGH INSIDE DRILL STEM

$$P = \frac{0.000061\ M\ L\ G^{1.86}}{D^{4.86}}$$

P = PSI, Pressure Loss.
M = #/Gal. Mud Wt.
L = Feet, Length.
G = GPM, Circulation Rate.
D = Inches, Bore Diameter, ID.

PRESSURE DROP ACROSS THE ROCK BIT NOZZLE

$$P = \frac{MG^2}{12{,}031\ A^2C^2} \qquad (C = \text{Orifice Coefficient})$$

C = 0.95 for High Velocity Jet Nozzles and Hard Bottom Cast Nozzles.
C = 0.80 for Drilled Water Courses and Insert Type Bull Plug Nozzles.

FRICTION LOSSES DUE TO FLUID RETURN THROUGH THE ANNULUS

$$P = \frac{0.000086\ M\ L\ G^2}{(D-d)(D^2-d^2)^2}$$

D = Inches, Major Annulus Diameter.
d = Inches, Minor Annulus Diameter.

Tri-cone Nozzle Diameter (X)"

$$X = 0.0606\sqrt{(D^2-d^2)}$$ for 225 Nozzle Velocity
for 150 Annular Velocity

Two Cone Nozzle Diameter (X)"

$$X = 0.075\sqrt{D^2-d^2}$$ for 225 Nozzle Velocity
for 150 Annular Velocity

TABULAR DATA

HOLE SIZE DATA			PIPE OD SIZE DATA		
Diameter	(Diameter)^2	Area	Diameter	(Diameter)^2	OD area
4 3/4	22.56	17.72	2 3/8	5.63	4.42
5 1/2	30.25	23.76	2 7/8	8.25	6.47
6 1/4	39.06	30.68	3 1/2	12.25	9.62
6 3/4	45.56	35.78	4	16.00	12.57
7 7/8	62.00	48.60	4 1/2	20.25	15.90
8 3/4	76.56	60.13	5	25.00	19.63
9 7/8	97.48	76.50	5 1/2	30.25	23.76

DRILL STRING DATA			NOZZLE DATA	
ID	(ID)$^{4.86}$	String description	Diameter	Area*
1.995	28.7	2 3/8 OD, 4.7# EUE API Tbg.	1/4	.049
			5/16	.077
2.441	76.2	2 7/8 OD, 6.5# EUE API Tbg.	3/8	.110
			13/32	.130
2.151	41.3	2 7/8 OD 10.4# DP.	7/16	.150
			1/2	.196
2.764	141.0	3 1/2 OD 13.3# DP.	9/16	.249
			5/8	.307
3.34	348.0	4 OD 14# DP.	11/16	.371
			3/4	.442
3.826	675.0	4 1/2 OD 16.6# DP.	13/16	.519
			7/8	.601
4.276	1175.0	5 OD 19.5# DP.	15/16	.690
			1	.785
4.778	1990.0	5 1/2 OD 21.9# DP.		

* For one nozzle only. Multiply by number of nozzles.

TABLE 7. Pump input horsepower. Assumed efficiency 76.5%.

	Circulation Rate GPM																
HP/lb of press.	60 .0458	70 .0534	80 .0610	90 .0687	100 .0763	110 .0838	120 .0916	130 .0992	140 .1068	150 .1145	160 .1221	170 .1297	180 .1373	190 .1450	200 .1526	210 .1602	220 .1679
Pressure (psi)																	
500	22.9	26.7	30.5	34.4	38.2	41.9	45.8	49.6	53.4	57.3	61.1	64.9	68.7	72.5	76.3	80.1	83.9
1000	45.8	53.4	61.0	68.7	76.3	83.8	91.6	99.2	106.8	114.5	122.1	129.7	137.3	145.0	152.6	160.2	167.9
1500	68.7	80.1	91.5	103.1	114.5	125.7	137.4	148.8	160.2	171.8	183.2	194.6	206.0	217.5	228.9	240.3	251.8
2000	91.6	106.8	122.0	137.4	152.6	167.6	183.2	198.4	213.6	229.0	244.2	259.4	274.6	290.0	305.2	320.4	335.8
2500	114.5	133.5	152.5	171.8	190.8	209.5	229.0	248.0	267.0	286.3	305.3	324.3	343.3	362.5	381.5	400.5	419.7
3000	137.4	160.2	183.0	206.2	229.0	251.4	274.8	297.6	320.4	343.6	366.4	389.2	412.0	435.0	457.8	480.6	503.6
3500	160.3	186.9	213.5	240.6	267.2	293.3	320.6	347.2	373.8	400.9	427.5	454.1	480.7	507.5	534.1	560.7	587.5
4000	183.2	213.6	244.0	275.0	305.4	335.2	366.4	396.8	427.2	458.2	488.6	519.0	549.4	580.0	610.4	640.8	671.4
4500	206.1	240.3	274.5	309.4	343.6	377.1	412.2	446.4	480.6	515.5	549.7	583.9	618.1	652.5	686.7	720.9	755.3
5000	229.0	267.0	305.0	343.8	381.8	419.0	458.0	496.0	534.0	572.8	610.8	648.8	686.8	725.0	763.0	—	—
5500	251.9	293.7	335.5	378.2	420.0	460.9	503.8	545.6	587.4	630.1	671.9	713.7	755.5	—	—	—	—
6000	274.8	320.4	366.0	412.6	458.2	502.8	549.6	595.2	640.8	687.4	733.0	—	—	—	—	—	—
6500	297.7	347.1	396.5	447.0	496.4	544.7	595.4	644.8	694.2	744.7	—	—	—	—	—	—	—
7000	320.6	373.8	427.0	481.4	534.6	586.6	641.	694.4	747.6	—	—	—	—	—	—	—	—
7500	343.5	400.5	457.5	515.8	572.8	628.5	687.0	744.0	—	—	—	—	—	—	—	—	—

* For one nozzle only. Multiply by number of nozzles.

TABLE 8. Drawworks input horsepower. Assumed pulling rate 100 ft/min.

	Hook Horsepower						Drawworks Input Horsepower (Based on 66% Transmission Eff.)					
	2⅜" Tbg -IF tool jt.	2⅜" 6.65# D.P.	2⅞" Tbg -IF tool jt.	2⅞" 10.4# D.P.	3½" Tbg -IF tool jt.	3½" 13.3# D.P.	2⅜" Tbg -IF tool jt.	2⅜" 6.65# D.P.	2⅞" Tbg -IF tool jt.	2⅞" 10.4# D.P.	3½" Tbg -IF tool jt.	3½" 13.3# D.P.
Horsepower required per 100 ft of drill stem.....	1.53	2.23	2.17	3.52	3.34	4.57	2.32	3.38	3.28	5.32	5.04	6.92
Length ft												
1,000	15.3	22.3	21.7	35.2	33.4	45.7	23.2	33.8	32.8	53.2	50.4	69.2
2,000	30.6	44.6	43.4	70.4	66.8	91.4	46.4	67.6	65.6	106.4	100.8	138.4
3,000	45.9	66.9	65.1	105.6	100.2	137.1	69.6	101.4	98.4	159.6	151.2	207.6
4,000	61.2	89.2	86.8	140.8	133.6	182.8	92.8	135.2	131.2	212.8	201.6	276.8
5,000	76.5	111.5	108.5	176.0	167.0	228.5	116.0	169.0	164.0	266.0	252.0	346.0
6,000	91.8	133.8	130.2	211.2	200.4	274.2	139.2	202.8	196.8	319.2	302.4	415.2
7,000	107.1	156.1	151.9	246.4	233.8	319.9	162.4	236.6	229.6	372.4	352.8	484.4
8,000	122.4	178.4	173.6	281.6	267.2	365.6	185.6	270.4	262.4	425.6	403.2	553.6
9,000	137.7	200.7	195.3	316.8	300.6	411.3	208.8	304.2	295.2	478.8	453.6	622.8
10,000	153.0	223.0	217.0	352.0	334.0	457.0	232.0	338.0	328.0	532.0	504.0	692.0
11,000	168.3	245.3	238.7	387.2	367.4	502.7	255.2	371.8	360.8	585.2	554.4	761.2
12,000	183.6	267.6	260.4	422.4	400.8	548.4	278.4	405.6	393.6	638.4	604.8	830.4

	Additional Horsepower Required for Drill Collars				
	3½" x 1¾" 24.5 lb per ft	3¾" x 1¾" 29.4 lb per ft	4⅛" x 1¾" 37.3 lb per ft	4¾" x 2¼" 46.7 lb per ft	5¼" x 2" 62.9 lb per ft
Horsepower required per 100 ft of drill collar.....	7.42	8.9	11.3	14.2	19.1
Drawworks input horsepower per 100 ft of drill collar.....	11.25	13.5	17.1	21.4	28.8

Undrilled Anticlines

of the California Eocene

Northeastern Ventura County May Yield Rich Rewards

Homer Steiny
Consultant, Los Angeles, California

SINCE the advent of the anticlinal theory for the accumulation of oil in the 1860's the visible anticlines in the sedimentary world have almost all been drilled, perhaps not deep enough, but they have been penetrated to a depth that, in most cases, was determined by the capacity of the driller's equipment, his pocketbook, or a combination of both.

A surprising exception to the foregoing statement exists in northeastern Ventura County, California. There, wide open to the wind and rain and sunshine of California, are not one but several major anticlinal folds that can be seen on the surface. Like the Kettleman Hills and other major anticlinal folds, those who lack geological imagination and those who are not "oil minded," have succeeded in uncovering a hundred reasons why these long folds are worthless. The drill will, of course, tell the story, and those who can see and possess the geological imagination will be rewarded.

These anticlines were early noted in the geological history of California, appearing in the notes of George H. Eldridge written in 1901 and 1902, and later crystallized into United States Geological Survey Bulletin No. 309, by Dr Ralph Arnold. Many other papers and articles have dealt with the area, and of special note is the monumental Bulletin No. 753, by W. S. W. Kew.

The Geological Column

Prior to talking about the several structures, a short review of geological column seems in order. The upper member of the Eocene series is the Cold Water sandstone. This is a white indurated sandstone, interbedded with maroon, sandy shales in thin strata. Beneath this is the Cozy Dell, a hard, brown, and green micaceous and sandy shale, with thin bedded, dark brown sandstones. Underlying the Cozy Dell are the hard, light-greenish gray, massive sandstones of the Matilija. These have occasional strata of dark brown, sandy shale intercalated in them. Below these three formations, the rocks are variously named but do include, in descending order, the Echo Falls shale, the Topatopa sandstone, the Sizar shale, and the Wheeler sandstone. These four formations are 5000 ft thick and are jointly called the Juncal by some and lower Las Llajas by others, with interfingering (of nomenclature) by many. Whatever the names may be, there are 5000 ft of sediments near the center of a 20,000-ft organic basin to be a trap for oil. It is the objective to drill through the upper, more dense shales and minor sandstones into these underlying, more porous formations.

EXCLUSIVE

The Anticlinal Structures

Of the several anticlinal structures recorded, probably the largest is the Topatopa anticline. It centers in the north tier of sections in T. 5n. R. 21w. As outlined in the accompanying map, its quaquaversal high is cut by the Santa Ynez fault. As, at least, the upper sections of rocks at this point are shales, they should be tight enough to prevent the dissipation of hydrocarbons to the surface. The Topatopa Anticline plunges for many miles from this point to the east and to the west, and on these two plunges, upper rocks are wrapped around it, and in the case of the east plunge, these overlying, wrapped-around rocks are oil producers.

The Mutau Anticline, located in the center of T. 6n. R. 21w, is an anticline in the same rocks as these under discussion. It has low angle flanks and its surface rocks are in the Matilija Sandstone group.

The Cuyama-Piru Anticline centers in the southeastern tier of sections in T. 7n. R. 22w. This is a larger and broader structure than the Mutau. It plunges westward and has its eastern closure against the Mutau Fault. This anticline is near the edge of the basin,

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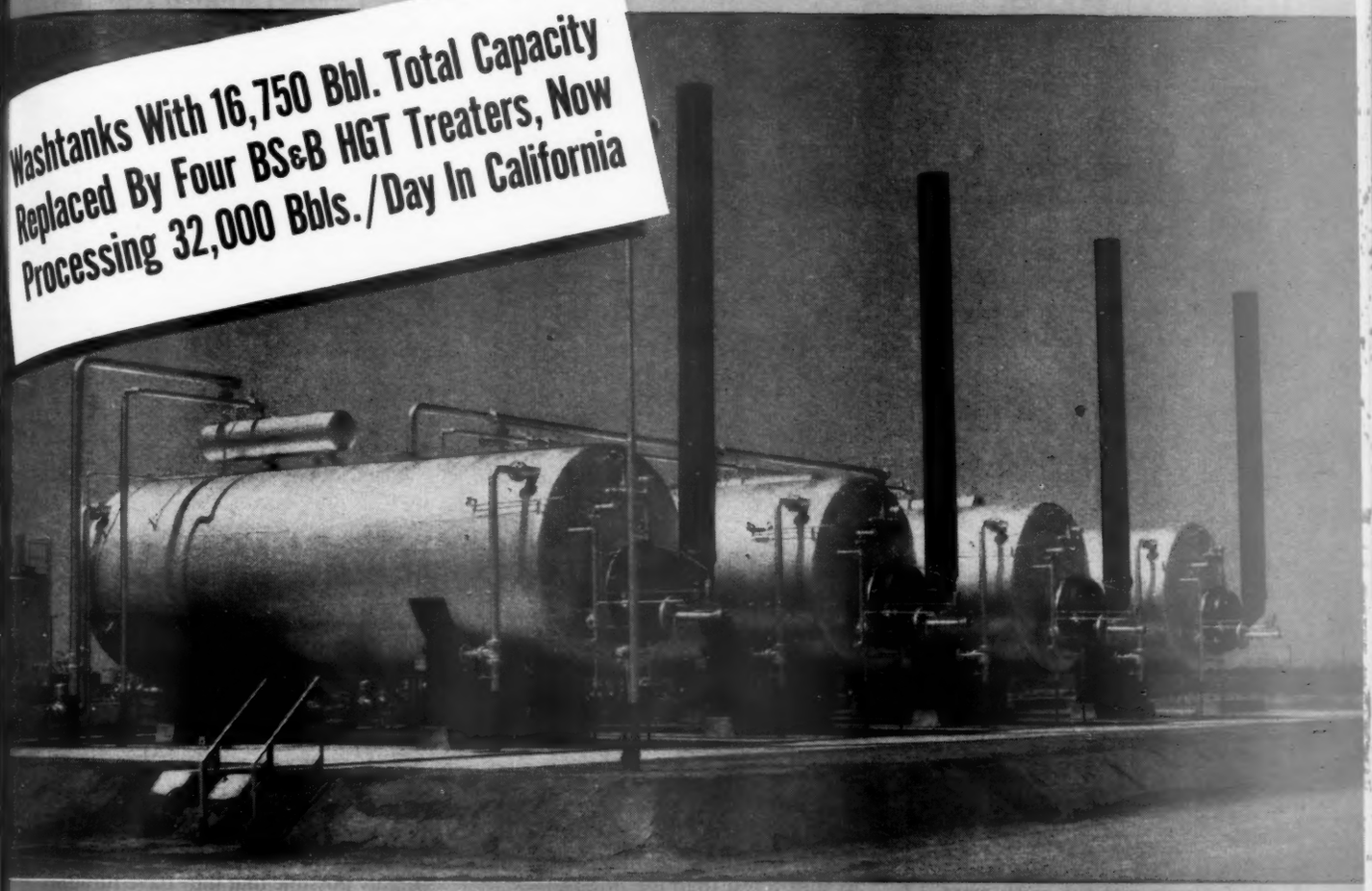

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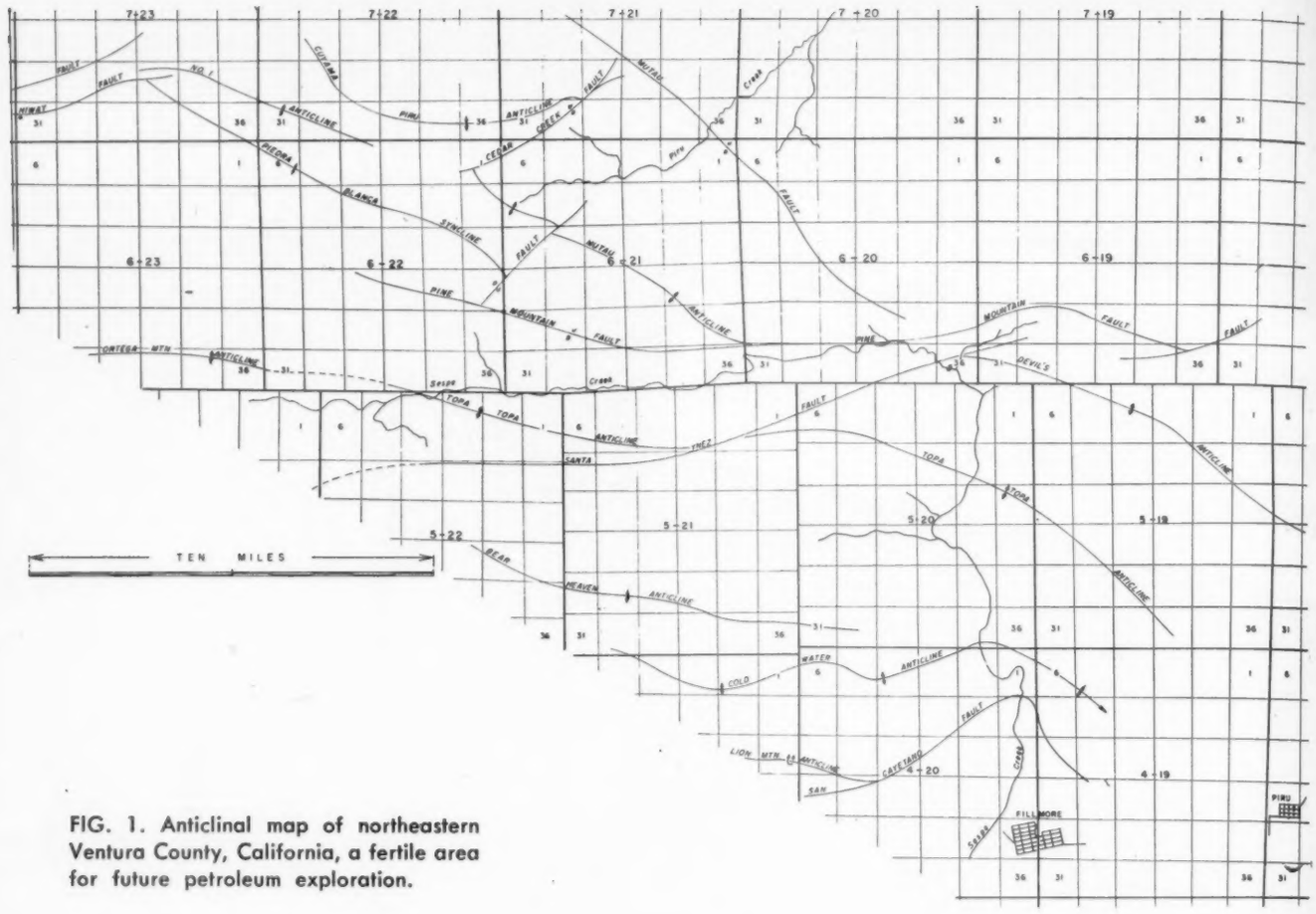

FIG. 1. Anticlinal map of northeastern Ventura County, California, a fertile area for future petroleum exploration.

The Author

Homer Steiny is a true grandson of the California gold rush as his grandparents came to California soon after, and because of, the discovery of gold there. He was born and reared in Stockton, California, and is a graduate of Stanford University. He was continuously employed in the geological department of the Tide Water Associated Oil Company and its predecessor, the Associated Oil Company, for over 35 years, 1918-1953 inclusive. He has been a member of the American Association of Petroleum Geologists since 1925 and has served on many of its committees. He was district representative from the Pacific Coast section and was president of the Pacific Coast section, 1951-1952. He is a member of the Geological Society of America and of the California Academy of Sciences. He is also a member of the Western Oil and Gas Association and has served on its oil information committee and its wildcat committee. He is now a practicing consulting engineer residing in Los Angeles, California.

and drilling would start lower in the section than in the other anticlines. It would, therefore, be a less costly place to start a test than the others.

The No. 1 anticline has Cozy Dell shales on the surface, with upper Cold Water sands wrapped around its western plunges. Its eastern closure is a small trough between it and the Cuyama-Piru Anticline.

The Cold Water Anticline is centered along the north tier of sections of T. 4n. R. 20w and its longitudinal range is generally east and west. The surface rocks at the quaquaversal crest are Cold Water sandstones, the highest formation of the Eocene section. The amount of the geological column to be penetrated by drilling on this structure will be limited by an underlying thrust fault. A well to the south, however, found this fault plane, and calculations indicate that there should be 9000 ft of Eocene sediments in the Cold Water Anticline. It is this anticline that seeps oil into Sespe Creek.

This structure has the great added advantage over the other four anticlines mentioned in that it is underlaid by a steeply dipping Pliocene and Miocene series, the Eocene having been thrust over these younger rocks, uptilting thm. As this series is well known as the great generators and producers of California petroleum, it is highly possible that they have furnished the Cold Water Anticline with a great amount of migratory oil. In addition, it is possible to drill through the Eocene and into these underlying porous rocks where a rich supply of this character of oil should be found.

In conclusion, here is a vast area, 24 miles from north to south and 30 miles from east to west. It lies in one of the big organic sedimentary basins of North America. There are a number of seepages in it, and the presence of oil in the nearby, overlying Sespe formation is quite generally attributed to those Eocene sediments as the generators. The anticlinal structures pointed out in preceding paragraphs are good, definite anticlines, recognized and mapped by many and over a long period of time. Two objections are: Lack of porosity and inaccessibility. The former will not be proved until they are drilled and tested, and the latter is surely easier than planting a derrick a mile out into the Pacific Ocean.

Someone, with geological foresight, will someday be rewarded with a lot of oil in this area. * * *

100-Foot Kelly Joint Saves Rig Time

Two 50-ft lengths joined together cut down on number of connections made

ROCKY Mountain Drilling Company of Los Angeles, California, experimenting with the use of a 100-ft kelly, has found that the company is saving considerable rig time and not experiencing any particular difficulties or inconveniences in handling and running the 100-ft section.

The section consists of two 50-ft, 6-in. square kellys fastened together with a pin and box connection with the threads machined so that the flats on the top and bottom section correspond when the threads are made-up. The four corners are veed out for a distance of about four inches above and below the joint, and V-shaped bars are welded in the slots to prevent the two kelly sections from breaking loose and rotating apart above or below the rotary table. The welds are then ground smooth to prevent interference when the kelly passes through the kelly bushing.

When moving to a new location, the steel bars are removed with a torch and the kellys separated into two standard, 50-ft sections to facilitate handling. The total time required for one welder to perform the separation and re-joining of the kellys is approximately three hours.

Rocky Mountain has found that the 100-ft kelly is not only a timesaver in that fewer connections are required to be made, but also considerable time saving is being realized in laying down and picking up rubbered pipe when running inside casing. Also, on several occasions it has been found that the extra working length is quite desirable in hight-hole conditions and fishing jobs.

The 6-in. kelly, in spite of its extreme length, has very little tendency to whip while rotating. The minimum-size surface pipe that the 100-ft kelly has been run inside of is 11¾ in. OD, and no contact between the kelly and the pipe was experienced.

So far, Rocky Mountain Drilling Company has drilled over 40,000 ft of hole with this unique kelly, and the company thoroughly satisfied with its performance. Suffice it to say that they

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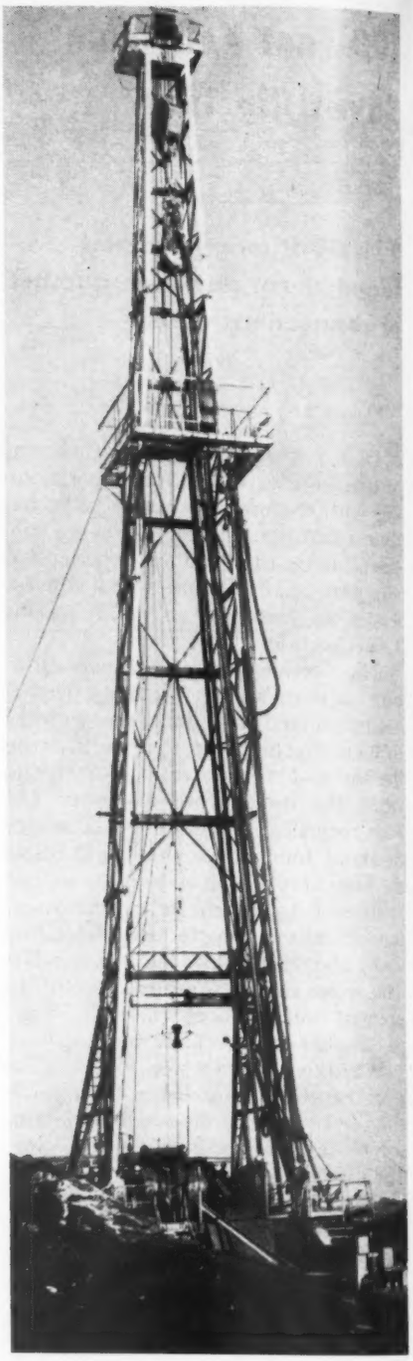

Hundred foot kelly joint being stabbed into rathole preparatory to making a connection on Rocky Mountain Drilling Company's rig 12, drilling Standard Oil Company of California's McGrath No. 4-1114 in the Montalva field, Ventura County, California.

drilled a 16,100-ft hole near Fillmore, California, in 78 drilling days to set a new record for that area. * * *

Unitization in Rangely Field

Voluntary unitization of Rangely field in Colorado has been urged by assistant secretary of the Interior Felix E. Wormser. Unitization of the field in Rio Blanco County would "insure conservation of the reservoir energy and make gas available some future date."

Rig Rests on Clay Pad

In Canada's Muskeg

Drilling equipment weighing more than 450 tons is supported by a clay foundation in the Cynthia area of Canada's Pembina field. General Petroleum of Canada, Ltd., moved the rig to location during the winter to drill for Texaco Exploration Company.

Photo courtesy National Supply Company

THE unstable nature of muskeg, coupled with transportation difficulties, influenced the Texaco Exploration Company to adopt special measures for drilling Texas Aurora 2-27 in the Cynthia area of Canada's Pembina field.

To give additional support for the weight of the rig and other equipment, a 7-ft pad of clay was packed down in a tract 400 by 550 ft, giving the effect of an island in the swamp-like muskeg. A landing strip for airplanes was built half a mile away. Helicopters are used at times when conventional aircraft cannot be landed.

The rig was moved to the location in winter, when the muskeg was frozen over. As it appeared, however, that the hole could not be completed before a thaw set in, the clay pad was built as an experiment to avoid having the rig trapped and out of operation for an extended period.

With its mast, substructures, and housing, the rig weighs about 100 tons. Another 375 tons of equipment and supplies are kept at the site. Muskeg, found in much of the Pembina field, as well as in other parts of the northern U. S. is a bog marked by spaghnum moss and tussocks and in its ordinary state would not support such a load.

When the present well is completed, the rig will be used to drill as many as four directional holes, according to present plans. A smaller rig, however, will be brought in for the directional work when conditions permit. Drilling is by General Petroleums of Canada, Ltd.

The location is on a 90,160-acre crown reservation tract at Cynthia, about 100 miles southwest of Edmonton, purchased by Texaco Exploration Company about a year ago from the Alberta government for a record-breaking cash bonus price of more than $13,000,000.

From the nearest supply store at Drayton Valley, 30 miles away, the location can be reached only by a cat trail that crosses several creeks and the Pembina River. As these streams have not been bridged, the trail is impassable for normal makes of vehicles except when the streams are frozen over or are shallow enough to be forded. In consequence, stockpiles of fuel, bits, and other supplies were built up, to make the location virtually self-sufficient. *

XUM

Officers of the American Association of Oilwell Drilling Contractors for 1954-55 as they appeared after being installed at the 14th annual meeting in Los Angeles. Seated, left to right, W. S. Fitzpatrick, Fitzpatrick Drilling Company, Corpus Christi, Texas, vice president for Gulf Coast; H. W. Davidson, Davidson Drilling Company, Midland, Texas, vice president for West Texas and New Mexico; Brad Mills, Dallas, executive vice president; Joseph V. Dunbar (deceased), Dunbar Drilling Company, Denver, president; C. F. Whaley, Chet Whaley Well Servicing Company, Houston, national vice president, who became president succeeding Dunbar; R. L. Manning, R. L. Manning Company, Denver, vice president for Rocky Mountains. Standing, left to right, Robert L. Rose, Drilling and Exploration Company, Los Angeles, vice president for California; W. L. McClusky, M. J. Delaney Company, Dallas, secretary; J. K. Butler, Oil Production Maintenance, Houston, vice president for Well Servicing; John J. Moran, Moran Brothers, Inc., Wichita Falls, Texas, vice president for North and West Central Texas, and Marion S. Church, Dallas, general counsel. Not shown in picture: Herbert Woolf, Woolf and Magee, Tyler, Texas, vice president for Cretaceous and Tertiary Basins; Gail C. Culter, Culter Drilling Company, Tulsa, vice president for cable tools; Dee A. Sikes (deceased), Helmerich and Payne, Tulsa, vice president for Central Mid-Continent; Alva C. Davis, Fairfield, Illinois, vice president for Illinois, Michigan, Indiana, and Kentucky; and Louis A. Beecherl, McDaniel and Beecherl, Dallas, treasurer. AAODC is holding its 1955 meeting in Houston September 25.

Drilling Contractors Association Plans Biggest Meet

Record Attendance Expected at 1955 Annual AAODC Meeting in Houston, September 25-28th

THE American Association of Oilwell Drilling Contractors' 15th Annual Meeting held at the Rice Hotel in Houston, Texas, September 25-28 was expected to attract record attendance. Approximately 1500 are expected to register for this affair. In addition to the general sessions, highlights of the meet include election and installation of officers, board of directors' meetings, committee meetings and reports, addresses by dignitaries, banquets, and parties.

The board of directors meet Sunday, September 25, and Monday will be devoted to registration and committee meetings. The Caterpillar Tractor Company will sponsor a buffet luncheon and Reed Roller Bit Company will put on a garden party at the River Oaks Country Club.

Registration will continue on Tuesday with two general sessions taking up most of the day. J. U. Teague of Columbia Drilling Company, Houston, will preside at the first general session, at which time the Honorable Roy Hofheinz, mayor of Houston, will make the welcoming address. The luncheon on Tuesday will feature the presentation of plaques by C. F. Whaley, AAODC president, to the chairman of the chapter that has demonstrated during the past year, the most outstanding improvement. A second plaque will be presented to the chairman of that chapter showing the greatest growth. A general session will be held Tuesday afternoon, with J. K. Butler presiding.

Highlight of Wednesday's meeting will be installation of officers at the luncheon. C. F. Whaley will preside. After a general session Wednesday afternoon, the meeting will conclude with a banquet at the new Houston Club. Frank S. Carothers, president, Norvell-Wilder Company, Houston, will be toastmaster, and the Honorable Allan Shivers, governor of Texas, will deliver the principal address.

Another featured speaker will be Harold Vance, vice president and manager of oil and gas department, Second National Bank, Houston. His address is "Financing the Oilwell Drilling Contractor." M. M. Brantley, president Brantley Drilling, will discuss "How Geology and Drilling Practices Affect Hole Deviation—A Study of a Typical Deep Permian Basin Field" with Stanley C. Moore, president, Drillo Oil Tools, Inc.

Warren L. Baker, vice president and director, Gulf Publishing Company, will speak on "Future Deep Drilling Prospects."

A post-convention tour of the Caribbean is offered for those desiring to take advantage of this special trip arranged by Jack Kirkwood of World Travel Bureau, Inc. Dates are from September 29 to October 11.

PROGRAM

15th Annual AAODC Meeting

Sunday, September 25

10:00 A.M. MEETING OF BOARD OF DIRECTORS

Monday, September 26

8:30 A.M. REGISTRATION

9:00 A.M. MEETING OF COMMITTEES

Insurance	Research and Education
Accounting	Membership and Dues
Cable Tool	Chapter Activities

12:00 Noon BUFFET LUNCHEON —
courtesy Caterpillar Tractor Company

2:00 P.M. MEETINGS OF COMMITTEES

Rotary Drilling	Taxation
Transportation	Safety
	Publications

6:00 P.M. GARDEN PARTY, River Oaks Country Club—
Courtesy of Reed Roller Bit Company

Tuesday, September 27

8:30 A.M. REGISTRATION

10:00 A.M. GENERAL SESSION
Presiding: J. U. Teague, Columbia Drilling Company, Houston
Invocation: The Rev. James P. Clements, rector, St. Marks Episcopal Church, Houston, Texas
Welcoming Address: Hon. Roy Hofheinz, mayor of Houston, Texas
1. President's Address: C. F. Whaley, Chet Whaley Well Servicing Company, Inc., Houston, Texas
2. Reports of Standing Committees
3. Report of Nominating Committee

12:15 P.M. LUNCHEON
Presiding: H. J. Chavanne, Prince Drilling Company, Houston
Presentation of Plaques: C. F. Whaley

2:00 P.M. GENERAL SESSION
Presiding: J. K. Butler, Oil Production Maintenance, Inc., Houston
1. "The Contractor Buys Insurance"—Joseph M. Shelton, Dallas
2. "Financing the Oilwell Drilling Contractor"—Harold Vance, vice president, Second National Bank, Houston, Texas
3. "Future Drilling Prospects"—Warren L. Baker, editor, World Oil, Houston, Texas

4:00 P.M. MEETING OF BOARD OF DIRECTORS

6:30 P.M. SUPPLIERS' PARTY, Sam Houston Coliseum, Houston

Wednesday, September 28

10:00 A.M. GENERAL SESSION
Presiding: Morris McDannald, Mac Drilling Company, Houston
1. "How Geology and Drilling Practices Affect Hole Deviation — a Study of a Typical Deep Permian Basin Field" — Stanley Moore, Drilco Oil Tools, Inc., Midland, Texas, and M. M. Ghee Brantly, Brantly Drilling Company, Inc., Midland, Texas
2. "Some Economic Aspects of Offshore Drilling Operations" — John Domercq, Jr., vice president, Standard Oil Company of Texas, Houston, Texas

12:15 P.M. LUNCHEON
Installation of Officers: C. F. Whaley

2:00 P.M. GENERAL SESSION
Presiding: Earle C. Hellums, Cron and Gracey Corporation, Houston
1. "Air and Gas Drilling Symposium" — by Special Subcommittee of the Rotary Drilling Committee — Guy B. White, chairman, Delta Drilling Company, Evansville, Indiana
2. "New Mud Desander Cuts Drilling Costs" — R. L. O'Shields, Salt Water Control, Inc., Fort Worth, Texas, and D. E. Wuth, Dorr-Oliver, Inc., Stamford, Connecticut
3. "Ten Years of Training with AAODC" — John Woodruff and R. L. Dailey, division of extension, The University of Texas, Austin, Texas

6:30 P.M. FELLOWSHIP HOUR, Houston Club

7:30 P.M. BANQUET, Houston Club
Presiding: C. F. Whaley
Toastmaster: Frank S. Carothers, president, Norvell-Wilder Supply Company, Houston, Texas
Address: Hon. Allan Shivers, Governor of Texas

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Jerry Stumm

Pacific Coast Editor

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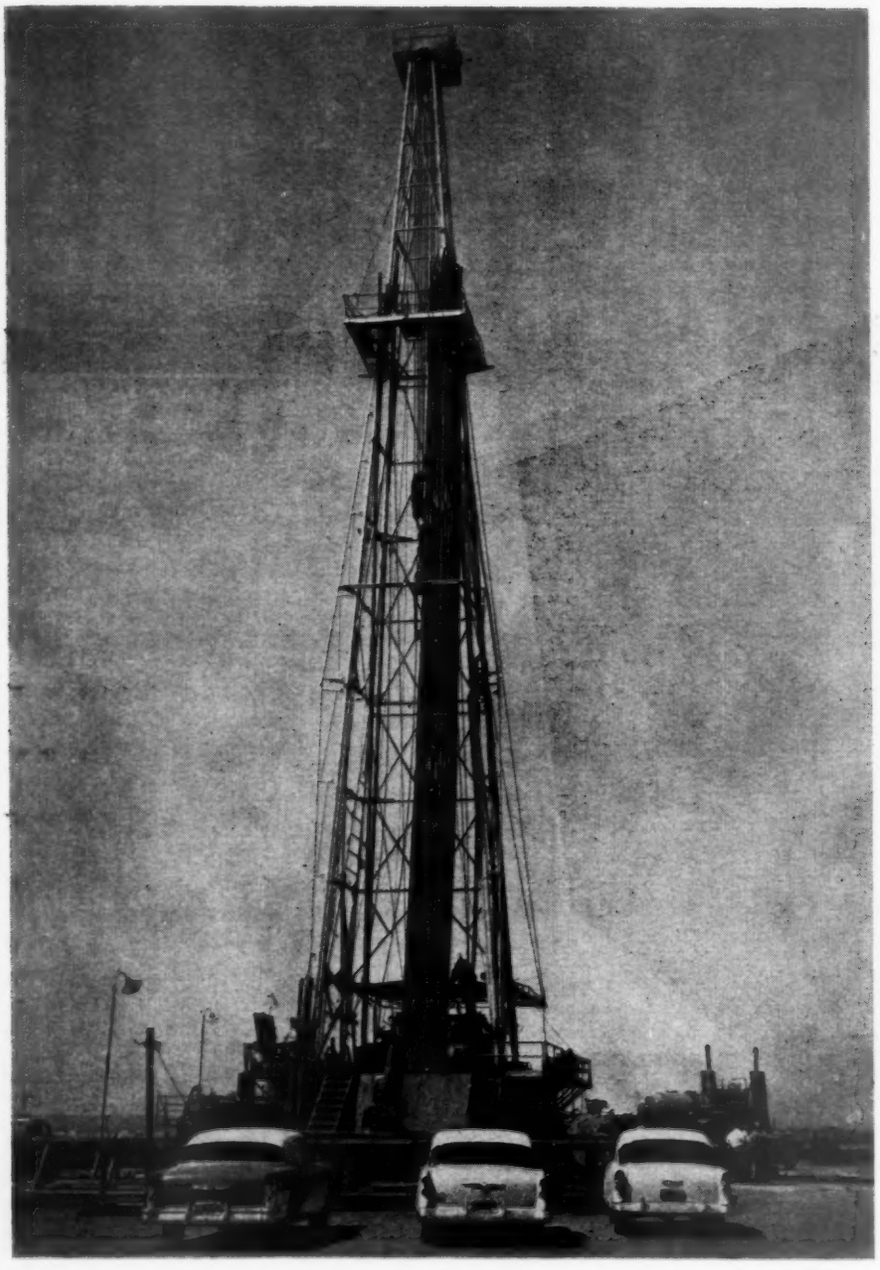
New, light-weight drill pipe with specially designed flash-welded tool joints are racked in Drilling and Exploration Company's rig No. 28, drilling the Lloyd Corporation's Barchard No. 4 in the Oxnard field, California.



THE first flash-welded tool joints on a light-weight drilling string have been used by Drilling & Exploration Company with excellent results for the first time in California. Record time was made by DrilExCo in drilling the Barchard No. 4 for the Lloyd Corporation to a total depth of 9174 ft in the Oxnard field. Although the string was stuck at 6200 ft, is was pulled successfully without any damage to the pipe. After the first test, it was felt the string could be used in drilling to 12,000 ft.

The string consisted of 4 in. OD, 10.46 lb-ft, 0.262-in. wall, grade N-80 tubing made with special internal upset ends. The tool joints, designed by Reed Roller Bit Company of Houston, Texas, are 4 in. by 5¼ in. OD, full hole joints with a special short pin so that the internal diameter is 3 in. rather than the standard 2 11/16 in. The joint utilizes a four-thread-per-inch, 2-in.-taper-per-ft API tool joint thread. The joint has a 1½-in. wide, hard metal wear band on the box that is raised above the outside diameter of the joint as shown in Fig. 1. In order to lighten the weight of the connection, overall length of the joint was cut down to 12½ in. This length provides 5-in. tong space on the pin and 7½-in. tong space on the box, including the 1½-in. hard metal band.

Weight of this string, with joints attached, is approximately 1200 lb per 100 feet. Of course, use of a light-weight drilling string requires additional drill collars to supply the desired weight on the bit. In this particular instance, 45,000 lb of 7½ in. OD drill collars were run to carry between 20,000 and 30,000-lb weight on the bit.

Hydraulics. The hydraulics of the string are excellent. Using 10 lb/cu ft mud and a flow rate of about 400 gpm, loss in the 4-in. tubing string is approximately 110 psi/1000 ft of pipe, vs 310 psi/1000 ft of 3½ in. OD, 13.30 lb IF drill pipe, and about 70 psi/1000 ft of 4½ in. OD, 16.60-lb drill pipe with full hole connections.

Pumps were compounded and 7-in. liners were used on the discharge pump and 6¾-in. liners on the pick-up pump. Pump discharge pressure varied between 1100 lb and 1800 lb using 9/16-in. jets on the bit. Mud volume varied between 400 and 500 gpm.

After drilling 1595 ft of 13⅜-in. surface hole, the well was completed with a 10⅝-in. hole to 9174 ft. Rotary speeds varied between 175 and 225 rpm. The drill pipe was run in tension at all times and, with completion of the hole, pipe and tool joints showed no more than normal wear.

Pipe Stuck at 6200 Ft. Ideal drilling conditions were purposely not selected for the initial testing of this light-weight drilling string. As many Cali-

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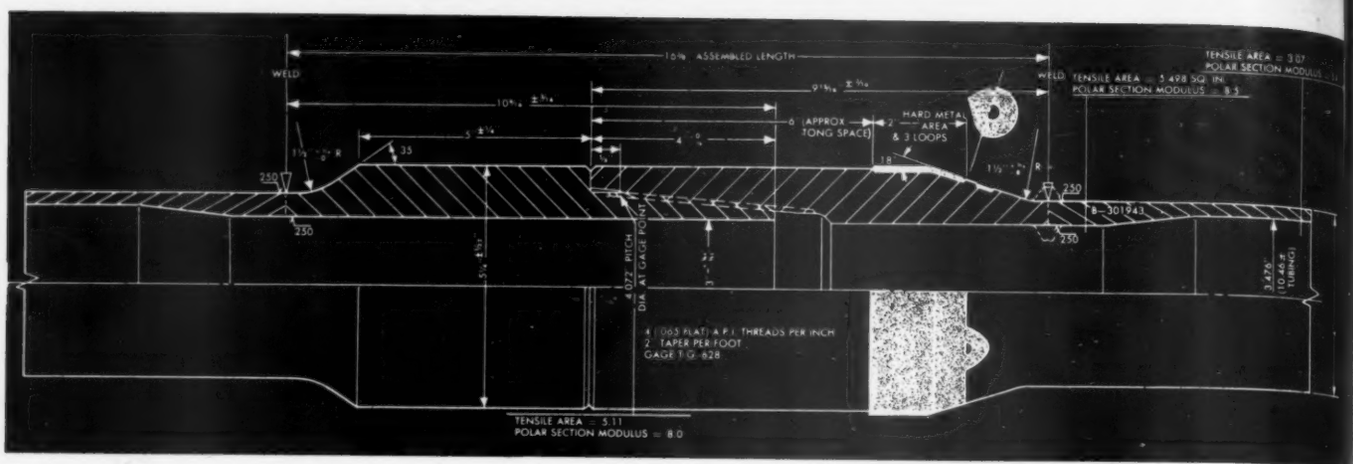

FIG. 1. Layout of specially designed full hole, short pin, tool joint, which was flash welded to special 4-in., 10.46-lb internal upset tubing.

fornia contractors will attest, drilling conditions in the Oxnard area, with its various hard formations all the way to severe unconsolidated sand conditions, makes it one of the toughest areas in the state.

At 6200 ft, with 101,000 lb of pipe in the hole, including 45,000 lb of drill collars, the pipe was stuck. It required holding a pull of about 200,000 lb while jarring back to the free-point approximately 10 times before the pipe was freed. When brought out of the hole, the pipe showed no indication of stretch or crookedness.

Other Advantages. With its 5¼-in. OD tool joints, this new light-weight pipe makes an excellent slim hole string. The joint, together with the 4-in. OD, internal upset pipe permits adequate elevator contact and good tool joint shoulder — face width so that OD wear is not highly critical.

The 0.262-in. wall of the tubing permits more possible wall wear than an equivalent weight tube in 4½-in. OD size. This latter tubing would also necessitate at least a 5¾-in. OD tool joint; hence it would be heavier and not fit the classification of a "slim hole" string.

The tool joint allows the string to be handled more like conventional drill pipe than does a lighter weight, smaller outside diameter connection. It also eliminates special equipment as required by tubing with couplings, such as power tongs and lifting plugs.

Drilling & Exploration Company also reported that its average round-trips were made as fast with this rig and light-weight drill pipe as those made with a larger rig using 4½-in., 16.60-lb. drill pipe, operating nearby in the same field. The latter rig is powered by three 350-hp gas engines, while the smaller rig is powered by three 245-hp gas engines. * * *

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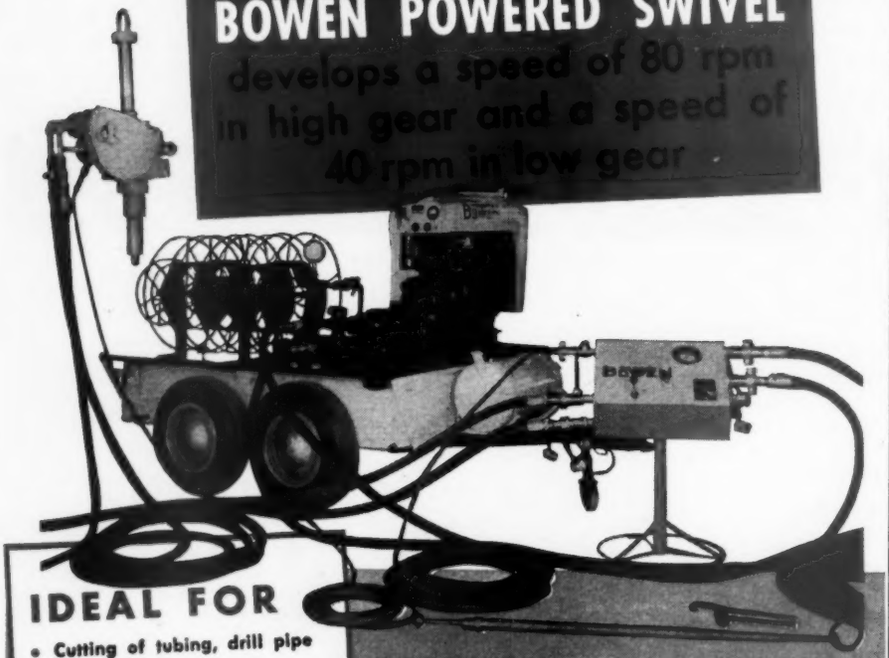

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- Cutting of tubing, drill pipe and casing
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- Scraping casing
- Drilling out cement
- Milling operations
- Backing out strings of rods, tubing, etc.
- Drilling rat holes
- Drilling out inside of drill pipe after a fire or other shut down time
- Milling out undersize I.D. of drill pipe tool joints to allow passage of cutters, etc.
- Maintaining circulation and rotation to prevent sticking of pipe while repairs are being made to the drilling rig.

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Bowen Powered Swivels eliminate the necessity of moving in kellys, rotary tables or other heavy equipment for light or medium short-time rotary work. They are sensitive enough for small torque operations like cutting with macaroni or sucker rods, yet sufficiently rugged to do clean-out and milling jobs.

3 TYPES of BOWEN POWERED SWIVELS MEET EVERY NEED

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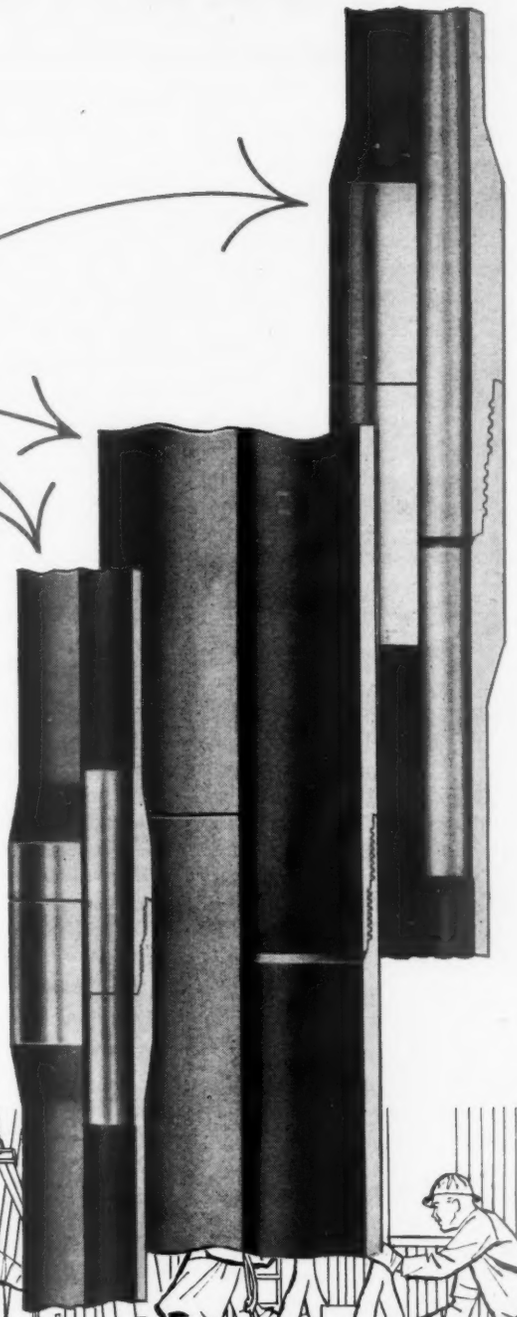

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Canada: Calgary, Edmonton.

EXPLORATION ACTIVITIES

KANSAS

★ Cities Service is completing its Lansing-Kansas City limestone discovery in Graham County, for an initial potential of 267 bbl of oil daily. The Blazier No. 1 discovery is approximately four miles north of the Schmied field and five miles north of Morland. Cities Service holds a 75 per cent interest in the discovery and other interests are held by Colorado Oil & Gas and Glenn W. Peel. Cities Service has 2890 acres in the block.

The potential was based on an eight hour pumping test in which the well produced 88.8 bbl of 41 deg oil from Lansing-Kansas City perforations between 3796 and 3804 and 3785 and 3793 ft.

AUSTRALIA

★ Drilling of its first well in the Gippsland area of Victoria has been begun by Frome Lakes Proprietory Ltd., in which The British Petroleum Company is a partner with Standard Vacuum Oil Company and Australian companies. The well is known as Darriman No. 1. The drilling which is being done on contract, is east of the Gippsland lakes where small quantities of oil have been obtained at shallow depths in the past by boring and shaft-sinking.

NORTH DAKOTA

★ Lion Oil Company has completed as an oil well the Carl No. 1 in Bottineau County. An east offset and a confirmation to the company's Skarphol No. 1 which was completed late in June as a field discovery. The Carl is flowing 5 bbl per hour of clean oil from the Mission Canyon formation. Total depth is 2983 ft. Lion owns a ⅝ interest in the new well and in leases covering 1120 acres in the immediate vicinity. These properities are owned jointly with Tomahawk Oil and Gas Company.

COSTA RICA

★ Union Oil of California has spudded its third test well in Costa Rica some 15 miles south of the Patino No. 2. The second well was abanded recently after going to a depth of 10,128 ft.

TEXAS

★ Fifteen miles southwest of Big Lake, in Crockett County, Cities Service's Shannon E No. 2 has been completed for an initial potential of 1515 bbl of oil daily. It is a southward extension of the West World Field in an area where Cities Service holds 4300 acres. The 24-hour potential was based on four-hour test during which the well flowed 252.5 bbl of 49.3 deg oil through a ½-in. choke. Flowing tubing pressure was 800 psi and gas-oil ratio was 1766 to 1. Drilled to a total depth of 9144 ft, the wholly owned well was plugged back to 8165 ft. Production is through perforations between 8106 and 8116 ft opposite the Strawn Reef formation.

★ Phillips Petroleum Company and Southland Royalty Company are completing the No. 1 Zulette, a large Ellenburger gas condensate discovery well in central Reagan County. The two companies hold an equal interest in 4513 acres around the new discovery, located 13 miles north-northwest of the town of Big Lake. The well flowed 543 bbl of 58.6 deg condensate in 24 hours through a small choke from 22 ft of perforations bottomed at 10,554 ft with a gas-distillate ratio of 3300 to 1. The wildcat previously indicated commercial possibilities from three other formations. It flowed at the rate of 288 bbl of oil daily from the Fusselman at 10,460 ft, recovered 390 ft of mud-cut oil from the Lower Wolfcamp at 8124 ft and recovered 540 ft of oil and gas-cut mud from the Spraberry sand at 5750 ft.

The well, the No. 1 Zulette, is located in Section 10, GC&SF Survey.

EGYPT

★ Casing has been set on International Egyptian Oil Company's Belayim No. 112-2 in the Sinai Peninsula area. The casing string was set to a depth of 8793 ft, just below a 150-ft solid oil sand section from 8600 to 8750 ft. Operator intends to core ahead below the casing, with the hope that the Oligocene-Eocene contact will be reached in the next 500 ft.

NEW MEXICO

★ Cities Service's significant Permo-Pennsylvanian reef discovery in Lea County has been assigned an 894 bbl daily potential by the New Mexico Oil Conservation Commission. The York No. 1 discovery has probed a 120-ft pay section. It is one mile west of the Eidson pool which produces from the Saunders (Pennsylvanian) limestone. Production is from selected perforations opposite the Permo-Pennsylvanian between 10,599 and 10,175 ft. Cities Service is planning offsets to the discovery.

The discovery is located approximately 10 miles west of Lovington. Gravity of the oil is 39 deg.

WASHINGTON

★ Richfield Oil Corporation has spudded Weyerhaeuser No. 1 wildcat, the first test of oil and gas potentialities in Wahkiakum County in the extreme southwestern corner of Washington. It has been classed by Richfield as a "no-dope hole". So far there have been no commercial oil or gas finds in Washington, although some showings have turned up in various areas. Three other wells are currently drilling in the areas of Forks, Aberdeen and Toledo.

ARIZONA

★ The state's second producer is in the offing by Humble at its No. 1 Navajo-Tribal in Apache County in the Four Corners area. Humble recovered 9,614,000 cu ft of gas per day. Well flowed 3 or 4 bbl of fluid hourly (from 5 to 20 per cent oil) from the Paradox section of Hermosa at a depth of 5560-95 ft. On a previous test at 4799-4831 ft, the well tested 1,800,000 cu ft of gas daily with a flow of 1.5 bbl of clean oil in one hour.

UTAH

★ A rank wildcat has been staked on the northern edge of Salt Lake City. The well is Hickey Oil Corporation's No. 1 City.

★ Gulf Oil is completing production tests at its No. 1 Coalbed Canyon Unit 15 miles southeast of Monticello in San Juan County. On a 7-hour test from perforations at 5762-5805 ft. The well flowed 43 bbl of condensate and 7,690,000 cu ft of gas per day.

★ A natural gas field has been opened with the completion of Sinclair's No. 1 Government-San Arroyo, located on San Arroyo Mesa in Grand County in the east central part of the state. Gas recovery from the Lower Dakota totalled 2,500,000 cu ft per day and an additional 600,000 cu ft was recovered from the Entrada.

★ Carter Oil et al No. 1 Larson-State has found gas in two zones of the Morrison. Initial test of this well, located 13 miles south of Sinclair's gas discovery, revealed 1,000,000 cu ft daily through open hole from a depth of 1045 to 1055 ft and 1,765,000 cu ft from a test at 1068 to 1084 ft.

★ White Canyon Mining Company, has completed its Sitton Mine No. 2 as a commercial gas well. Drilling on Sitton No. 3 has continued at 5723 ft and two pay formations were encountered above that depth with these formations thicker and higher in gas unit count than in No. 2.

OKLAHOMA

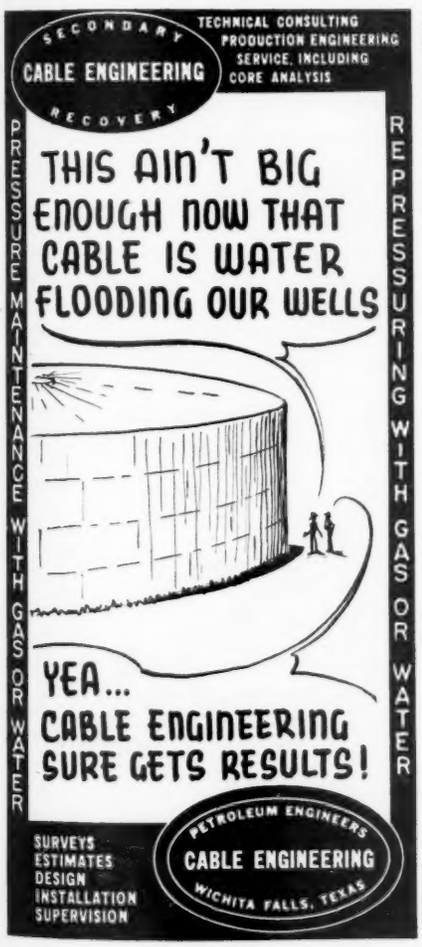
★ Union Oil Company has reported today that tests of its new wildcat gas discovery well in Beaver County, Oklahoma, show the well has a calculated open flow potential of 48,000,000 cu ft of gas per day through a 5½-in casing with 17 bbls of 60 deg condensate per million cu ft of gas. The well, Parker No. 1, is shut in.

★ Atlantic Refining Company is going ahead with plans to drill a rank wildcat in Harmon County, 30 miles from existing production in the extreme southwestern part of the state. The well is the No. 1 Martha Snider.

★ Powel Briscoe, Inc's., is discovery well north of the Northeast Luther pool, Oklahoma County, has recorded flows of 25,000,000 cu ft per day and 13 bbl of oil per hour, natural, from perforation in the Hunton Lime at 5110-20 ft. The well, the No. 1 William F. Cutting, topped the Hunton lime at 5070 ft.

ILLINOIS

★ Drilling has been spurred in the Kinkaid sector of Christian County as the result of a wildcat drilled by the Lama Oil Company. The well, a no-dope hole, tested 20 ft of the Hardin sand from 1780 to 1800 ft with a calculated potential of 1254 bbl daily.



CALIFORNIA

★ Atlantic Oil Company is drilling a wildcat ½-mile south of production in the Rosedale field, seven miles west of Bakersfield in Kern County.

★ Oceanic Oil Company has abandoned the deepest well ever drilled in the Midway-Sunset field, Kern County. CWOD D-3-7, located two miles southwest of Fellows, explored to a total depth of 12,514 ft without finding commercial production.

★ Reserve Oil and Gas Company, having almost fully developed its share of the Jewett pool at Tejon Ranch, is now preparing to drill two new wildcats. The new tests are Reserve No. 76-13 on Sec. 13, 11-19, which will constitute the first well ever drilled on Sec. 13. The other test in Reserve, E. W. Pauley No. 65-33, two locations south and one location east of Jewett production.

★ Sunray Mid-Continent Oil has moved in to drill a test well near Nicolaus in Sutter County, 20 miles north of Sacramento. The well is known as Lienert No. 55-29, near the center of Sec. 29, 12-4, and is expected to explore to around 6500 ft.

★ Standard Oil of California's wildcat drilled on Yuba Consolidated Gold Fields, Inc.'s 168-acre lease in the Fillmore area of Ventura County, has been abandoned at 15,500 ft. Simultaneously, Standard abandoned its Harrison Ranch 2-2 well, on Sec. 27, at 15,979 ft.

★ Warren L. Meeker completed his Lomita Land No. 4 well as a new fault block discovery in the Sunset Beach area of Orange County. The hole was completed flowing 420 bbl per day of 29 gravity oil from intervals between 6540 ft to the total depth of 6750 ft.

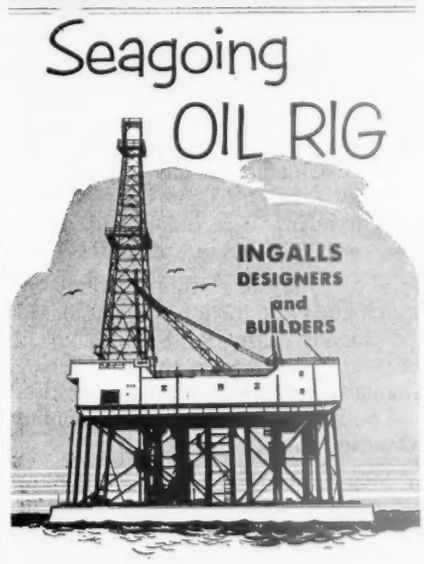
★ Standard Oil Company of California will drill another deep test in the Fillmore area of Ventura County. The hole will be known as Kuenstler Unit No. 1 and will drill to about 15,000 ft.

LOUISIANA

★ A well near Burrwood on the west bank of the Southwest Pass of the Mississippi River in Plaquemines Parish has been successfully completed by Shell Oil and The California Companies. The well, Shell-California State Lease 2565 No. 1, on a production test flowed at a daily rate of 308 bbl of 29.8 deg oil and 102,000 cu ft of gas through a 9/64-in. choke from perforations in the interval from 10,649 to 10,679 ft. The well was drilled under contract for Shell as unit operator by Gulf Coast Rig No. 1 to a total depth of 13,402 ft and plugged back to 10,679 ft. The tubing pressure was 2375 psi.

CANADA

★ Canadian Delhi Oil Ltd., operator for the Delhi-Husky Oil & Refining Ltd.-Phillips Petroleum Company-Richfield Oil Corporation group has completed a two-mile step-out to the Bone Creek field in Southwestern Saskatchewan as an indicated commercial producer. The well is Delhi-Husky-Phillips-Richfield Bone Creek No. A 16-23. A drillstem test of the A2A member of the Jurassic formation gave a recovery of 2850 ft of oil and 30 ft of oil-cut mud in 60 minutes. A drillstem test of the J2B gave a recovery of approximately 1000 ft of clean oil.



What's doing in DRILLING

★ Since 1864—just five years after Colonel Drake's discovery—drilling operations in Cuba have been underway. In fact, over 2000 wells have been put down on the island in the last 90 years, although no real key to Cuba's oil potential has been discovered.

★ The veil is soon to be lifted, as a boom is well underway. Most recent news from the area reports that Stanolind and two Cuban firms have already begun exploration operations stemming from contract negotiations completed in September. The two Cuban companies, Trans-Cuba Oil Company and the Cuban Venezuelan Oil Voting Trust (composed of 24 participating companies) and Stanolind have concessions to 12,000,000 acres.

★ Boom was kicked off with the Kerr-McGee-drilled discovery last year in the Jatibonico Basin. The first well, which came in at 100 bbl per day, was reported to have logged 37 oil zones. The Corporacion General de Petroleo, which made the discovery, now have five wells—the only producers on the island.

★ Gulf has spent $5,000,000 in Cuba, the newly organized Siboney is already is pouring in cash. A score of other American and Canadian companies are at work. Sixty geologists are busy and several rigs are now drilling. Some of the others now in Cuba are Atlantic Refining of Cuba, California Exploration (a Richmond of California affiliate), Compania Petrolera La Estrella de Cuba (Shell), Cuban Gulf (Gulf), Esso Standard, West Indies, Ltd. (Texaco), and Standard of California.

★ C. J. Simpson Drilling Company, anticipating production has purchased the Socony refinery at Olean, New York and is moving it to Cuba. Jersey Standard now has a unit in operation and both Shell and Texas are planning refineries there.

★ Stepped-up activity in southern France has brought that country in focus, with prospecting licenses being issued at a fast clip. Esso Standard S. A. F. is now drilling two wells, Parantis Nos. 11 and 13, offshore from the discovery well. The Parentis field, it is estimated, can supply France with 6 per cent of the country's needs.

★ Additional exploration has been planned in France in the Paris Basin by American Overseas Petroleum France S. A. F. and Societe Nationale des Petroles du Languedoc Mediterraneen. Two seismic crews, one American and one French, are now at work south of Paris on four sections of 5000 sq km. Amofrance is a member of the Caltex group of companies and the other participant is controlled by the French government and private interests.

★ A year-old report by the Oklahoma Geological survey is credited stimulating new activity in Pontotoc County, Oklahoma. Griffith Drilling Company is under contract for George P. Caulkins, Jr., an Oklahoma City independent to drill to 4600 ft or into the Reagan sandstone. The well is the No. 1 Norris Ranch, eight miles southwest of the Fitts field and 12 miles northeast of Sulphur. The report that has spurred activity in the area was written after Frankfort Oil drilled a thick section of the Arbuckle near Sulphur and found oil and gas shows. Data indicates the Reagan objective will be about 100 ft thick.

★ What's behind sudden increases of drilling activity in different activity? In the case of the Pontotoc County spurt, it was an old survey. We give Siboney and Kerr-McGee a lot of credit for present activity in Cuba. Nevertheless, it takes a good well before many operators go out on a limb. Deeper than the first question is the query concerning the purpose of that first well. Sometimes a long list of costly dry holes lies behind the initial producer; sometimes long years of geological study is involved, sometimes the discovery is accidental.

★ In Freedonia, Kentucky just such an accident occurred recently. It seems the Freedonia Civic Club decided the town needed a water well. The sum of $200 was collected and given to a man from nearby Princeton to drill a well. At a depth of 225 ft, the driller found oil and as the story goes—a small-scale oil boom is underway. Freedonia still needs water.

★ Long and frequent tests in one area are responsible for many field discoveries. Take Jack W. Frazier of Houston, Texas, for instance. He has been plugging away (literally) in Liberty County, Texas, for just about as many years as anyone cares to remember. He has what looks like a big thing about 1½ miles south southeast of the Hardin field, a Frazier discovery. The well is the Wirt Davis No. 1 and tested several zones before being bottomed at 9018 ft.

★ Falcon Seaboard Drilling Company is celebrating its twentieth anniversary. The company, which began with one rig in 1935, now operates 28 rotaries in seven states. Behind the company are five generations of oil men, dating back to President T. N. Law's great grandfather, William Barnsdall, who founded the first oil refinery in the world and drilled the first well after Drake. The last generation is now represented in the company by T. N. Law, Jr., who is Falcon Seaboard's insurance and safety director.

★ Frank Wood Associates, Inc, and Frank Wood and Brothers, Inc., drilling contractors and producers of Wichita Falls, Texas, have sold all capital stock to The Texas Company. Texaco is operating the firms under present names, and Texas men have assumed executive positions.

Stanolind Oil and Gas Company, of Tulsa, and Trans-Cuba Oil Company and Cuban Venezuelan Oil Voting Trust of Havana are undertaking an exploration and drilling program in the areas outlined on the map. Involving a total of some 12 million acres, the program is the largest ever planned in Cuba.

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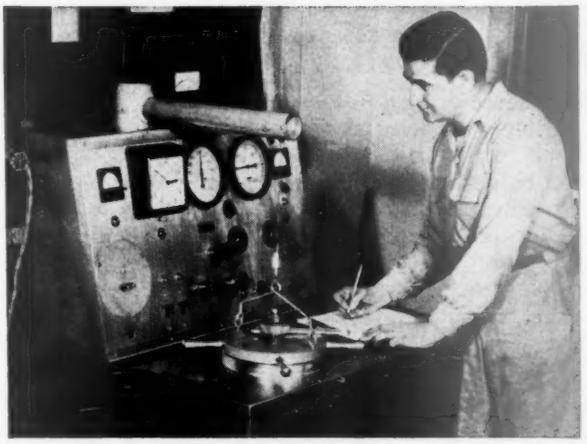

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Rigbuilders at work in Paupa, where British Petroleum is also associated with American and Australian interests in the search for oil. Drilling of Omati No. 2 well has been stopped at 10,880 ft, as technical experts found no prospects of encountering commercial gas or oil within reach of the drill in this hole. About 100 miles to the west the Aramia well has reached a depth of some 4,700 ft.

★ The Big Chief Drilling Company of Oklahoma City, Oklahoma, which recently acquired an interest in oil properties of Hilton Drilling Company of Great Bend, Kansas, has rigged up a brand new rig. The rig No. 32 is 8078 ft deep on a well for Sohio Oil. Toolpusher on the new "baby," incidentally, is Sam Dotson.

★ Offshore drilling in California will probably be delayed until next spring due to an anticipated six-month lag in lease bid red tape, a state official has told oilmen. Although laws have just recently granted drilling from barges and platforms, some 265,000,000 bbl of oil have already been taken from submerged lands via onshore drilling. The state has also collected lease royalities amounting to $1000,000,000.

★ Although the drilling contractor doesn't need to be told, the IPAA has reported that drilling costs have increased between 10 and 15 per cent over last year. The cost per foot drilled today runs between $12 and $15 compared with the $8 and $10 in the 1937-1941 period, and the total volume of drilling this year is estimated at 2½ times the pre-World War II level.

★ Drilling inside the city limits of Conroe is finally slowing up — simply because Humble Oil & Refining, the operator, has just about drilled up all possible locations. The company has drilled 28 wells on the townsite since the discovery in February, 1954. Officials indicated that Humble would continue until all sites were drilled on and that drilling would be advanced outside the corporate limits.

★ Standard of California is making preparations for a second exploratory well southeast of Prineville in Crook County in the central part of Oregon. The company has just completed a dry hole near Astoria, in Clatsop County. In the western part of the state, near Eugene, in Lane County, Sinclair is putting down a wildcat. Another is underway in the eastern part of the state near Vale in Malheur County by the same operator.

★ In a California field discovered 32 years ago, Union Oil of California has brought in a well flowing 1000 bbl per day of 36.2 deg crude, with tubing pressure of 1000 psi. The well, Callender No. 134, was drilled on an undeveloped fault block in the north central portion of the Dominguez field, in Los Angeles County.

★ Shallow drilling activity is up in North Dakota as a result of Sohio Petroleum's potential discovery in Renville County about 30 miles from the Canadian line. Sohio's discovery, the No. 1 Ritter, was in the lower Charles or the Mission Canyon at a depth of about 4500 ft. Several other operators in the Williston Basin are reported to be looking for the same zone. Carter Oil has just taken a near solid block of 175,000 acres near the discovery, some 30 miles west of the North Dakota-Minnesota boundry and 23 miles south of the Canadian border.

★ American Association of Oilwell Drilling Contractors' Battelle Institute has completed its report on the effects of drilling fluids on rock bit penetration. Results of the study would suggest that more attention will be given the hydraulic design of drilling bits. Report, among other things, evaluated highly the use of sodium hydroxide solution in drilling fluids for use as a limestone hardness reducer, as determined in performance tests.

★ Hancock Oil Company has completed its sixth well on the Alamitos lease in the Seal Beach area of California. Initial production was 600 bbl per day of 33 gravity oil from an interval between 7948-8400 ft. Since the company made the discovery last December, it has operated one drilling rig continuously. All of the first six wells are flowing and the company is now drilling its seventh. Seal Beach will probably be the site of first offshore drilling in that state.

★ General Exploration Company, as operator, completed its twelfth producing well in the Bandini area of East Los Angeles flowing 300 bbl per day of 39 deg oil from the Buckbee zone at 6465 ft. Others interested in the 1200-acre play include Basin Oil Company, Bolsa Chica Oil Company, Christopher Oil Company and C. G. Willis. Total production for the group in the field, which was discovered in September, 1953, now amounts to 1400 bbl per day. Another well is currently drilling.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Aug. 15	Aug. 22	Aug. 29	Sept. 5
Pacific Coast	140	138	135	134
Oklahoma	325	337	329	331
Kansas	185	187	195	197
Rocky Mountains	315	296	302	301
Canada	217	204	213	218
Ark-La-Tex	160	162	163	164
West Texas and New Mexico	542	536	520	525
Gulf Coast	595	619	595	625
Illinois	142	149	143	146
North Texas	331	339	339	343
	2952	2967	2934	2984

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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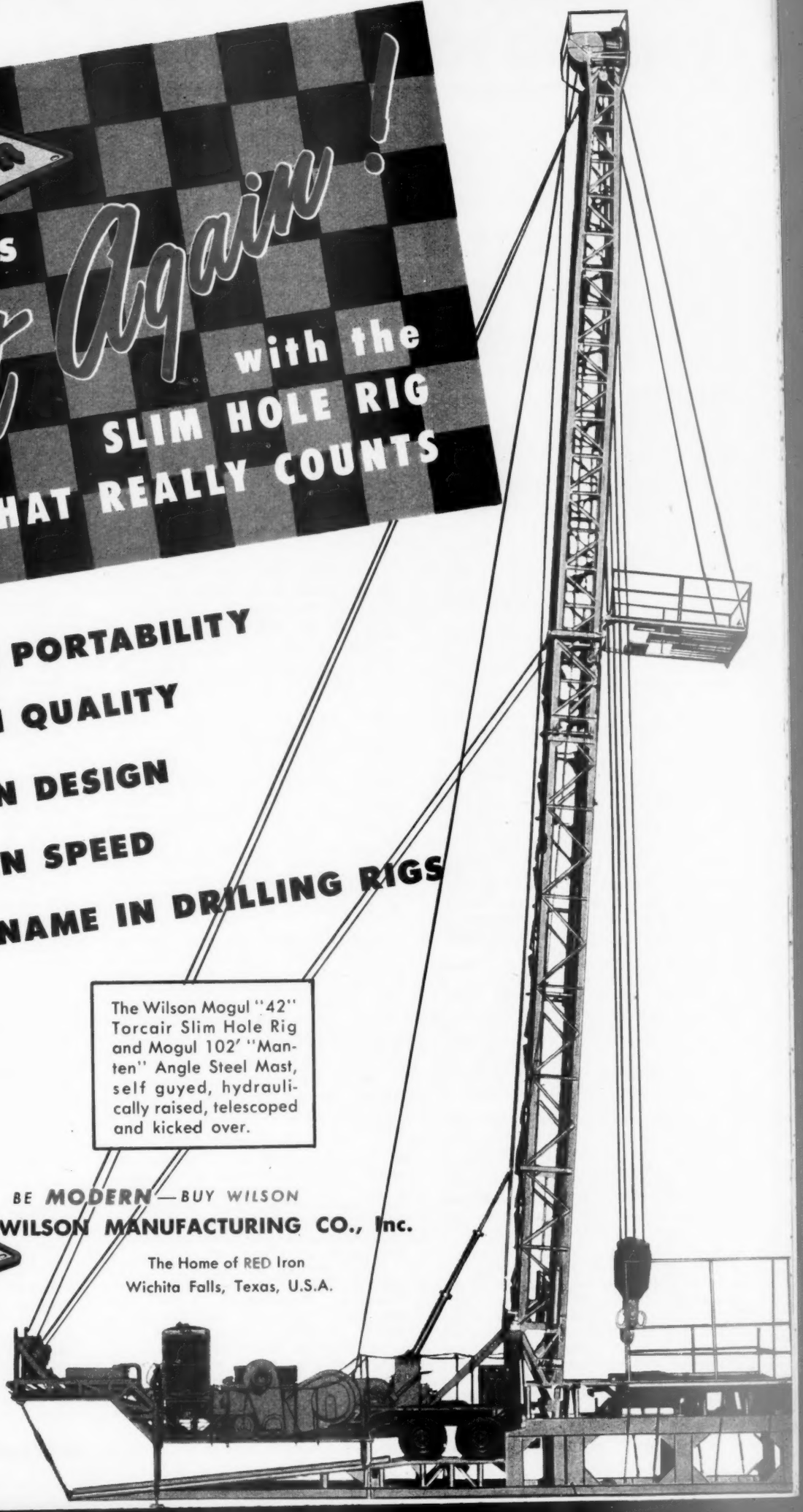

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R. R. McDaniel has opened offices in Calgary, Alberta, under the firm name of McDaniel Consultants Ltd. McDaniel will do oil and gas reservoir evaluation consultation work in the Calgary area.

W. M. Osborn and **John T. Miller** have announced the formation of a partnership to engage in geological consulting and general oil operations under the firm name of Osborn and Miller, with offices in Midland, Texas.

Dr. Frederic H. Lahee, one of the few men ever presented the American Association of Petroleum Geologists' coveted Sidney Powers Memorial Medal, retired from active duty with Sun Oil Company September 1. Dr. Lahee has been with Sun 37 years — 27 of them as chief geologist at Dallas and the last eight as geological and research counselor for the company's production department.

Dr. F. H. Lahee

As college professor, author, administrator, counselor, and pioneer in the gathering and use of reserve and exploration data, he has become one of the best known figures in the field of petroleum geology. In 1953 the AAPG selected him as the seventh man ever to receive its highest award, the Powers Medal. He also has become widely known as chairman of the American Petroleum Institute's Committee on Crude Oil Reserves, the highest authority on the nation's petroleum reserves. In recognition of his meritorious service and contributions, the API awarded him its Certificate of Appreciation in 1952. He received his AB, AM, and PhD degrees from Harvard University. He taught geology at Harvard from 1906 to 1912, and at Massachusetts Institute of Technology from 1912 until he joined Sun in 1918.

His textbook, "Field Geology," which he wrote while teaching at MIT, now is in its fifth edition. It has been widely used in universities abroad as well as in the United States. Dr. Lahee edited the AAPG's "Bulletin" from 1929 until 1932, when he was elected president. He was associate editor of "Problems of Petroleum Geology," a special publication of the AAPG.

Dr. Lahee is a member of the Mid-Continent Oil and Gas Association, Geological Society of America, Society of Economic Geologists, American Institute of Mining and Metallurgical Engineers, American Association for the Advancement of Science, Phi Beta Kappa, and Sigma Xi, as well as the AAPG and API.

John H. Trescot, Jr., has been appointed assistant manager of the oil department, Climax Molybdenum Company. Trescot's appointment was announced as part of an expanding program of investments by Climax in water flood properties and semi-proven royalty purchases. Before joining Climax, Trescot was connected with the pipe line department of Shell Oil Company.

Robert D. Brown, of Robert D. Brown Investments, Houston, Texas, was elected president of Target Petroleums, Ltd., Ontario, Canada and **Edward Suttles,** partner of Suttles Industrial Development Company, Houston, Texas was made secretary-treasurer at the company's annual stockholder's meeting. New directors include **William A. Cobban** of Toronto, a barrister and solicitor and general counsel for the company; **Joseph S. Irwin,** consulting geologist of Calgary, Alberta; **Howard Bowman,** oil operator of Calgary; **Gaylen Jones** of Calgary; and Brown.

Kilburn E. Adams, Jr. is being transferred from Tulsa to Houston as senior geologist on the staff of the general manager of the producing department of The Texas Company.

Adams is a geology graduate of Wesleyan University in Connecticut and joined Texaco in 1933 as a clerk in the Boston division office, sales department. He has been assistant division geologist, Oklahoma division, in the Tulsa office for the past three years.

Promotion of **Robert H. Martin** to division geologist, Rocky Mountain division of The Texas Company's Producing Department, has been announced. Martin joined The Texas Company as a geologist in 1942 at Mattoon, Illinois. In April, 1954, he became senior geologist, general manager's staff, at Houston.

J. F. Dean has been named assistant head of the petroleum engineering section, production department, Creole Petroleum Corporation, Caracas, Venezuela. **Paul N. Weidner** will head the petroleum engineering section, production department, replacing **W. S. Glendening,** named assistant western division manager, in Maracaibo. **M. L. Allen** has been appointed acting office engineer, petroleum engineering section, production department, Caracas, during vacation of **V. A. Acheson.**

Wesley Chalfant has been appointed assistant to the regional landman in Lion Oil's regional office at Denver. **Fred A. Glassco** and **Kenneth Lane,** both district landmen, will exchange offices. Glassco has been transferred from the Casper District of the Rocky Mountain Region to the Wichita District of the Central Region. Lane will take over the post of Casper district landman. **Clive G. McKnight, Jr.,** has been employed as regional scout in the Denver Regional Office.

Standard-Vacuum Oil Company has named **Harry A. Gibbon** to the newly-created post of producing coordinator at the company's New York headquarters office. Gibbon will coordinate all of Stanvac's exploration and production activities throughout the Eastern Hemisphere.

Albert Wright, Jr., former assistant general manager of Standard-Vacuum Petroleum Maatschappij (SVPM), the company's Indonesian affiliate, and a former coordinator for Stanvac's Indonesian affairs at New York, has been appointed assistant to the producing coordinator. For the past two years Wright has been with the International Petroleum Company, Ltd. at Coral Cables, Florida.

W. Caldwell

H. E. McKinney

Watson Caldwell, district geologist for Sunray Mid-Continent Oil Company at Lake Charles, La., has been promoted to Gulf Coast division geologist with headquarters in Tulsa, Oklahoma. Caldwell will supervise geological operations for Sunray Mid-Continent in south and east Texas and in Louisiana. His appointment became effective September 1. He replaces **Joe Peerson** who has resigned. Caldwell joined the company in 1953 as district geologist in Lake Charles. Previously he was with Signal Oil and Gas Company in Houston, Texas.

Howard E. McKinney has been promoted to manager of the newly-created engineering department of Shell Development Company's exploration and production research laboratory in Houston, Texas. McKinney joined Shell's research staff in November of 1943 and has been a senior engineer since 1950. Following his graduation from the University of Oklahoma, McKinney taught mechanical engineering at the University of Texas for several years. He also participated in National Defense Research Council wartime research projects at the university.

Harold W. Coryell has been appointed to fill the new position of patent liaison man in the Houston area. Coryell is officed at Shell Development's exploration and production research lab and is available to Shell Oil and Shell Chemical personnel in and around Houston to offer guidance in patent matters. Coryell is an experienced patent agent, having spent five years with the United States Department of Agriculture's southern regional research laboratory in New Orleans in addition to three years with Shell Development Company's patent division in Emeryville, California.

Maynard H. (Jack) Steig has been appointed vice president in charge of exploration for Lloyd H. Smith, Inc. of Houston, Texas. Steig was formerly exploration manager of the southeast region for Phillips Petroleum Company of Bartlesville, Oklahoma with whom he has been associated since 1938. After graduation from the University of Wisconsin in 1925, he spent five years in Mexico with the Mexican Gulf Oil Company, three years with Houston Oil Company and five years with Shell Oil Company.

Lowell N. Applegate has been named assistant vice president in charge of production for Falcon Seaboard Drilling Company. Applegate comes to Tulsa from Bartlesville following seven years with the production department of Phillips Petroleum Company, where he has been assistant reservoir engineer for the Gulf coast area since 1952.

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Over 50 *Locations in the United States and Canada*

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Service *Anywhere Anytime*

New Services • • • New Tools • • • New Methods • • • Outstanding Results

Locates Pay Sand Missed by Electric Log

In a shallow well in Oklahoma the McCullough Radiation Well Log picked up 23′ of pay that had been missed by an electric log.

The electric log had picked a hard limestone as the pay zone 5½" O.D., 14 lb. casing was set to bottom. Limestone formation was perforated and found dry. Then McCullough was called to run a Gamma Ray Log. At approximately 1100′, and just below the hard limestone, the McCullough Log picked up 23′ of shaley pay sand. This entire productive zone had been missed by the electric log.

The accurate and reliable information supplied by the McCullough Radiation Well Log (Gamma Ray and Neutron Curves) provides a sound basis for perforating for completion . . . always Log AND Perforate by McCullough.

Efficiency of McCullough Services Saves Operator Valuable Rig Time

Only 7½ hours were required to log, perforate and set a packer in this Texas well.

5½" O.D., 17 lb. casing was cemented at 7716′. Well was logged by McCullough from 7716′ to 5000′, obtaining gamma ray and neutron curves and recording a simultaneous collar log. Twenty McCullough Standard Casing Glass Jets, four per foot, were shot in the interval from 7482′ to 7487′. This was followed by setting a production packer at 6410′

In this series of operations there was no delay of any kind – a tribute to the efficiency of McCullough tools and instruments and to the skill of McCullough service crews

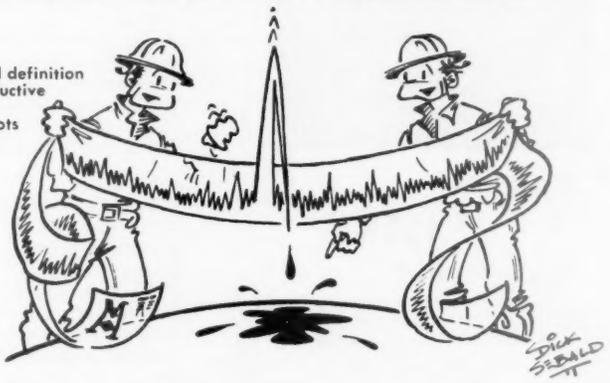
$2,433.21 SAVED

Accuracy of McCullough Radiation Well Log Prevents Wasting 390 Perforating Shots in Non-productive Shale Zones... Helps Increase Production 178 B/D

The decision to run a McCullough Radiation Well Log was worth $2,433.21 to this California operator 390 shots would have been wasted in dry shales except for the discovery of a ten-foot error in electric log measurements.

Well had been bottomed at 11,237′ and the electric log was run in open hole. A 5½" O.D., 23 lb. slotted liner was set through the productive interval. Well was put on production and slowly settled down to 22 barrels per day.

Operator decided to perforate liner to attempt to increase production. It was known that there were eight zones separated by shale beds to be perforated. A McCullough Radiation Well Log was run to exactly locate these zones and to check previous measurements. When correlated with the old electric log it was found that there had been a ten-foot error in depth measurement.



Exact measurement and definition of any potentially productive interval, thick or thin, assures "putting the shots where they count" for greater production — more oil!

The eight zones were perforated with a total of 1332 shots, four holes per foot, from the detailed data provided by the McCullough Log. 660 of these were ½" improved Ogival Bullets fired by 3½" O.D., McCullough M-3 guns, 2 holes per foot. The remaining 672 shots were fired by McCullough Standard Casing Glass Jets with Steel Strip Carriers, 2 holes per foot.

Production increased from 22 to 200 barrels of oil per day.

This job particularly emphasizes the extreme value of the accuracy and efficiency of the McCullough Radiation Well Log to the operator. Engineers of this company estimated that, had the well been shot by the old electric log measurements, 390 of the 1332 shots would have been placed in the non-productive shale beds separating the pay zones. At prevailing prices this would have meant a loss of $2,433.21 because of wasted shots. In addition the resulting production would have been considerably lower because of improper coverage of the eight zones.

It always pays to run a McCullough Radiation Well Log before perforating.

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To obtain more information on products advertised see page E-51

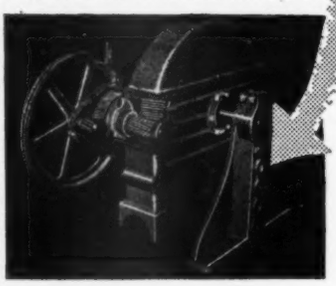
Running Tour

▸ Five new employees have recently been added to the Rocky Mountain regional production and exploration staff of Lion Oil Company, El Dorado, Arkansas. The five are **Richard A. Struble, Curtis J. Little, Norman E. Smith, Duane L. Roberts** and **Grover C. Williams.**

Struble was formerly a geologist for Atlantic Refining Company. Little came to Lion as a geologist in the Casper, Wyoming, district office. Smith is making Bismarck, North Dakota, his home after assuming the position of landman at the Bismarck office. Roberts joins Lion as production foreman at Fort Morgan, Colorado. He was previously a branch manager of the National Tank Company at Fort Morgan. Williams, a 1949 graduate of Texas Christian University, has joined the Colorado production district as a drilling foreman at Fort Morgan, Colorado.

JENSEN's

DOUBLE GEAR REDUCTION...



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Superiority!

JENSEN'S Double Gear Reduction is an engineering masterpiece. It enables one man in the field to change gear reductions — from single to double or from double to single — quickly and easily. The one-man combination counterbalance is another advantage that makes JENSEN JACKS more practical and economical. See your JENSEN Dealer, or write us.

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▸ Humble Oil and Refining Company has announced the following changes in its production department supervisory personnel. **J. H. Atterbury, Jr.,** associate petroleum engineer, petroleum engineering division, Houston Office, was promoted to petroleum engineer in the Southwest Texas division office. **J. H. Walvoord,** toolpusher, California area, was promoted to assistant district superintendent at Grand Isle district, Louisiana division.

J. F. Homer, assistant district superintendent, Grand Isle district, was promoted to district superintendent of the Bayou Sale district, replacing **J. F. Barrett,** who is serving as assistant division superintendent of the Southwest Texas division during the absence of **R. R. McCarty,** temporarily with Standard Oil Company (New Jersey) on a loan basis.

W. B. Wise, petroleum engineer, Talco district, East Texas division, was transferred to the Winters district, North Texas division, as petroleum engineer, replacing **T. R. Hicks,** who moved to Talco as petroleum engineer.

N. B. Frickman, senior petroleum engineer, North Texas division office, was transferred to the Bakersfield district, California area, as district petroleum engineer. **Conrad Thomas,** roustabout gangpusher, Mallalieu district, Louisiana division, transferred to the Talco district, East Texas division, as leasepumpergager. **C. D. Ehrhardt, Jr.,** supervising petroleum engineer, Gulf Coast division office, transferred to the proration division, Houston office, as supervising petroleum engineer.

H. D. Attra, junior petroleum engineer, Stratton district, was promoted to associate petroleum engineer at Stratton. **H. C. Worzel,** junior petroleum engineer, Government Wells district, was promoted to associate petroleum engineer, petroleum engineering division, Houston office. **John H. Pittman,** senior civil engineer, Julian gas construction district, transferred to the Gulf Coast division as senior civil engineer.

▸ **John R. McKay** of Calgary, Alberta, Canada, has been appointed regional supervisor in charge of the Canadian region operations for Plymouth Oil Company with headquarters in Calgary. This is a new position with Plymouth Oil Company following the opening of their Canadian region offices in Calgary last month. In addition to being headquarters for Canadian operations, Plymouth's Calgary office will also be in charge of operations in the states of Montana, North Dakota and South Dakota. McKay resigned his position as production manager of Banff Oil, Ltd., to accept the new position. Prior to his association with Banff, McKay had been division petroleum engineer of British American Oil Company, Ltd., senior engineer for California Standard Oil Company, and had also been a petroleum consultant.

▸ Members of the 1955 drilling committee of the Alberta division of the Canadian Petroleum Association have been appointed by the board of directors. They include **R. W. Brinkerhoff,** Brinkerhoff Drilling Company; **R. H. Gibbons,** Duke Drilling Company Ltd.; **R. L. Binning,** General Petroleums of Canada Ltd.; **J. W. Wark,** Hi-Tower Drilling Company Ltd.; **C. A. Nabors,** Parker Drilling Company Ltd.; **C. E. Thornton,** Reading and Bates Drilling Company; **S. B. Deal,** Shell Oil Company, and **E. Thurston,** Mobil Oil of Canada.

▸ **C. W. Stephens,** formerly division petroleum engineer in the Ohio Oil Company's Los Angeles division, has been appointed senior petroleum engineer and will be assigned special duties by the division manager. **W. B. Emery, II,** petroleum engineer at Bakersfield, California, has been named Los Angeles division petroleum engineer succeeding Stephens.

▸ **R. J. Dobson,** chief exploitation engineer for Shell Oil Company's Houston area, has been promoted to area production superintendent. He replaces **W. S. Crake,** who has received an overseas assignment at The Hague. Taking over the duties of chief exploitation engineer is **H. J. ten Broeke,** who is being transferred to Houston from the company's Calgary, Canada, area.

▸ **J. L. Hall,** head of the drafting and geologic departments of The Ohio Oil Company, Los Angeles, retired July 31 after 12 years with the company. Previously, Hall was employed with the Chanslor-Western Oil & Development Company for 21 years. Hall is opening a private drafting service for oil accounts at his home in Arcadia, California.

▸ **W. C. "Dick" Palmer,** division manager for Ashland Oil and Refining Company, Inc. at Midland, Texas, has resigned to join the Crow Oil Corporation in the capacity of division manager of their newly created Midland division office in that city. The Crow firm, with present offices in New York and Dallas, was recently organized and is engaged in the exploration for and the production of oil.

W. C. Palmer

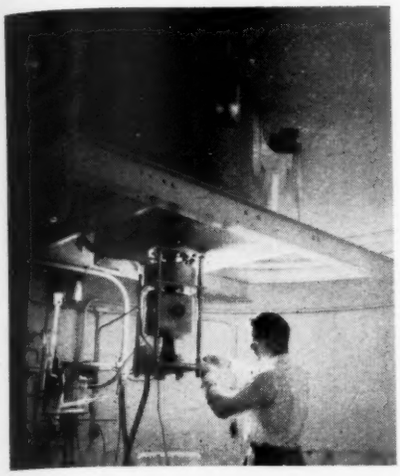
Palmer served three years with Ashland as division manager of its Midland division. Prior to that time he was associated with the Stanolind Oil and Gas Company in their land department in Oklahoma City, Oklahoma, Abilene, Texas and the Williston Basin Area.

▸ **Tom E. LeRoy,** formerly with the Phillips Petroleum Company in Houston, has been named division exploration manager for the Gulf Coast area by Southern Production Company, Inc. The oil and gas producing firm with headquarters in Fort Worth, Texas has moved its Gulf Coast division headquarters from Baton Rouge to New Orleans, Louisiana. **G. R. Henson,** former division exploration manager, will remain in Baton Rouge as a special representative of the company. **J. M. Van Dyck** will continue as the company's division landman.

Twelve veteran employes in the Panhandle district of Southern Production have received service awards recently at the annual barbecue in the company's district office in Pampa. Receiving the awards were **G. C. Delver,** 25 years' service; **R. B. Brown, J. K. Gotcher, R. L. Holley, J. B. Lowe, P. S. Rogers,** and **G. E. Tinnin,** 20 years; **W. A. Rainbolt,** 15 years; **E. V. Fulton, J. T. Robertson** and **J. A. Stewart,** 10 years; and **W. A. Smith,** five years. Service lapel buttons were presented to the recipients by **Dick T. Fenwick,** Southern Production vice president and head of the company's production department.

DIGEST of NEWS and COMMENT ★ ★ ★

Refining . . . Petrochemical . . . Gas Processing



First industrial linear atomic accelerator on the East Coast is already being operated by Atlantic Refining Company. This "gun" operates at 1,000,000 electron volts (1 mev) and can be boosted to possibly as high as 10 mev. As an example of what has been accomplished, Atlantic researchers have made a rocket fuel, hydrazine, $H_2N\text{-}NH_2$, by bombarding ammonia with this radiation. With this unit, the company expects to be able to disintegrate and re-form hydrocarbons more precisely than has been the case with thermal and/or catalytic methods now in general use.

★ ★ ★

Oil Industry Salaries Highest. Heartening indeed are the results of a recent survey of technical and scientific graduates from a large number of colleges and universities (C&EN). Every student investigated had at least two interviews for jobs, many had 15 or 20. Strangely, the number of students with chemical degrees going on for graduate work greatly outnumber those with chemical engineering degrees; that is, chemical engineers are going out into industry, etc., more than are bachelor graduate chemists. This may be explained by the greater number of offers received by Ch.E. graduates as compared to chemist graduates—3.2 offers per person and 4.5 offers, respectively. Graduates going into petroleum companies, large and small, received $200 to $300 per year more than those going into other lines. PhD's starting salaries averaged $542 to $675 per month, with a government median of $575. Teaching salaries are much less, averaging some $368 per month. Median monthly salaries for PhD's in petroleum were $600 per month and more, for master's degrees in petroleum ranged from $501 to $550, and in other fields $100 per month lower. BS degrees called for $400-$500 in petroleum, electrical, and pharmaceutical lines, and $375-$400 in other fields.

The petroleum industry attracted the greatest number of graduates of all degrees. Organic chemical manufacturing drew the next greatest number. A commentary on the present status of the teaching profession is shown by the fact that no BS or MS graduates had any plans for going into teaching; 15 per cent of the PhD's interviewed had gone into college teaching.

★ ★ ★

New Terephthalic Acid Synthesis. Competition for the role of base intermediate in the synthesis of this acid, important in synthetic fiber production, is being offered by a new process, developed by Henkel of Duesseldorf, Germany, in which the dipotassium salt of phthalic acid or anhydride—derivable from xylene, etc.—is heated in a carbon dioxide atmosphere to about 650 F to form the dipotassium salt of terephthalic acid. This job can be done by using potassium benzoate, 'tis said. Thus p-xylene, derived by fractionation from both petroleum and coal tar aromatic fractions, may have to fight for its "place in the sun" as the now prime raw material for this acid.

★ ★ ★

Fertilizer Unit for Spain. Spanish industrial interests led by Compañia Española de Petróleos (CEPSA), Madrid, are making preliminary plans for an ammonia fertilizer company to make the products from waste liquid and gaseous refinery materials. No further details are forthcoming.

★ ★ ★

Yankee Polyethylene for Britain. Union Carbide says it will build a plant for polyethylene production near Grangemouth, Scotland, to be on stream by mid-1957, to make 26,000,000 lb per year presumably for the British market. ICI (Imperial Chemical Industries), huge British chemical combine, has been the sole producer in the U.K. so far. ICI's patent for high-pressure polymerization runs out early in 1956. Bakelite, Ltd., another of the "children" of Carbide, will sell the production plant to be operated by GEMEC Chemicals. This will make Carbide a producer in three countries, U. S., Canada and Britain to the amount of nearly 300,000,000 lb per year of this polymer.

New Radioactivity, Electronics Section for Sun Oil. Advancements in petroleum refining technology and the growing use of radioactive tracers, electronic computers, and data logging devices by Sun Oil Company have led to its organization of a new applied physics section. This new section is part of the engineering division of Sun's manufacturing department and is located at Newton Square, Pennsylvania. Dr. E. Neil Shawhan has been appointed manager of the new section and Einar T. Young has been named assistant manager. A major portion of the work of the new section will be devoted to improvements in the efficiency of refining processes. The group will work on a wide range of projects for Sun's manufacturing department, including problems involving economies in the use of water, steam, and electric power; reduction in equipment first cost and maintenance, and in safe working conditions.

★ ★ ★

Rubber 'White Elephant' on Block?? Deadline for bids to buy the Institute, West Virginia, rubber plant is October 7, says an announcement from Washington, as "Ike" signs a bill to permit selling this "controversial" unit to private industry. This closes out, possibly, the last of the 27 government-owned rubber plants; 25 have been sold to industry; the 26th has been leased. The Akron, Ohio, rubber research laboratory, a $2,200,000 laboratory built by the government, is to be governed by an 11-man commission that will decide its disposal after a time while continuing its work. In this commission are such outstanding leaders as Frank Howard, ex-SOD president; Farrington Daniels, department of chemistry head, University of Wisconsin, and A. C. Cope, head of chemistry department, Massachusetts Institute of Technology.

CORRECTION:

Two errors occur in the article "Determination of Total Carbon Dioxide by Evolution," page C-20, August, 1955 issue of the Refining & Petrochemical Edition, as follows: Line 4 of paragraph "Sample Runs," should read "Optimum size of sample is such as to contain 10 to 20 mg of CO_2. If necessary, add enough CO_2-free water to bring the volume to approximately 50 ml." Under summary, line 20, the proper word is oxidize, not oxide.

—Editor.

Ethyl research chemist synthesizes a complex additive molecule—perhaps one that has never been made before.

No. 399 puts Ethyl Research nearer the answer

At last count our chemists had just developed compound No. 399 in the search for a gasoline additive to combat a specific engine-fuel problem—so today we're just that much closer to a solution of the problem.

It's no secret that "finding" a new additive takes time and imagination. For example, before we developed "Ethyl" Antiknock Compound, several thousand different elements and compounds were tested. And more than 300 compounds were tested before the new "Ethyl" Diesel Improver was perfected.

Usually a petroleum additive depends for its action on a single chemical element or grouping of elements. To find it may take months or even years of research.

The next step—and often the most difficult—is to discover the best chemical structure to contain the element. How can its atoms be arranged so that it will act at just the right time and place? Many new compounds (some of which have never been made in any laboratory) may have to be synthesized before the right one is found. This calls for the highest type of creative ability.

It is in additive development that the vast knowledge and experience of Ethyl Research is so important. Our contacts with both the petroleum and automotive industries give us a unique insight into fuel needs. That's why you can continue to look to Ethyl Research for advancement in petroleum additives.

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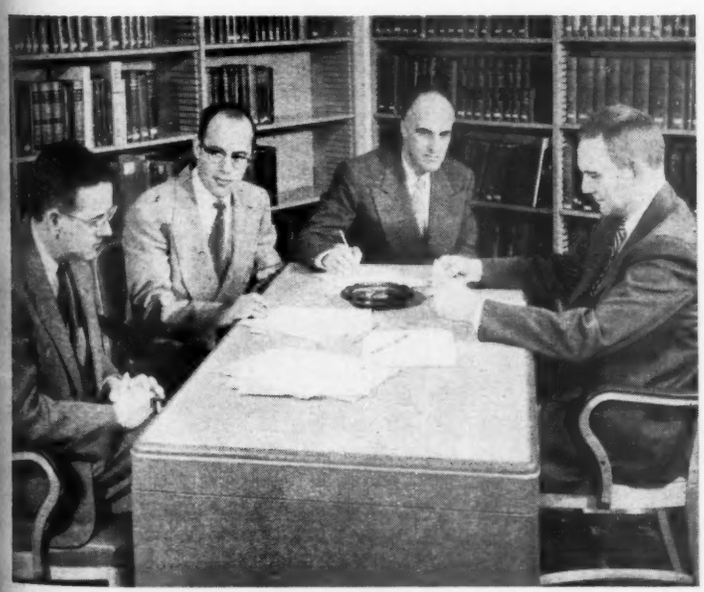

Evaluation of every additive calls for the combined talents of experienced research chemists and engineers.

Additives synthesized at Ethyl Laboratories represent thousands of hours of laboratory work.

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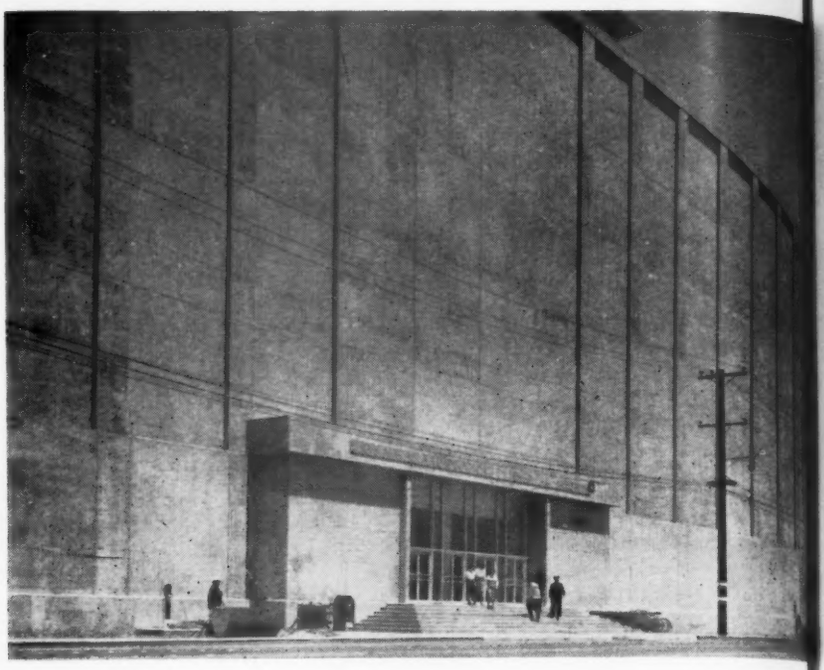

FIG. 1. A photo of the front entrance of the U. S. Naval Radiological Defense Laboratory; note the windowless construction, which is both a precaution against outside contamination with radioactive effects, and is a more economical construction design.

Atomic Explosion Dangers

Atomic Defense in the Oil Refinery

Four dangers from atomic blast are: heat wave, prompt radiation, blast wave, and 'fallout'

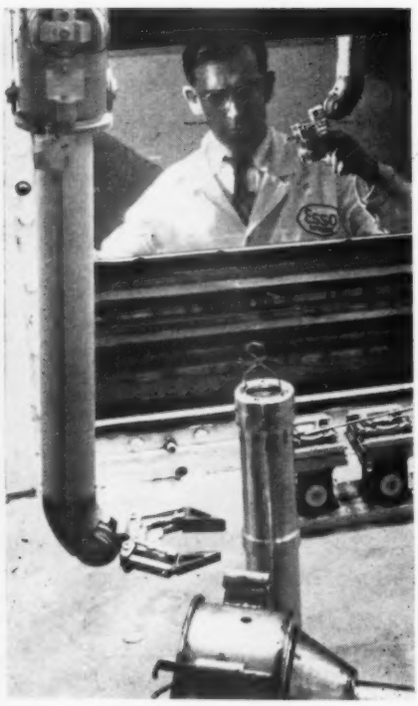

FIG. 2. By remote control the operator, behind screening material, handles radio-active cobalt with mechanical hands.

Dimitri A. Kellogg
Major, U. S. Army

THE oil industry is perhaps the most vital civilian component of our national defense. In an emergency, weapons and vehicles can be repaired for a time without replacement, but this is not the case with fuels and lubricants, which are required on a daily basis by all three armed services—Army, Navy, and Air Force. This lesson was brought home to me very forcibly during World War II while I was in command of an engineer aviation battalion in the Philippines. We were able to overcome sporadic shortages of spare parts by making some in our shops and by cannibalizing broken equipment for others, but the one time a typhoon broke the ship-to-shore fuel pipe lines and forced the tankers out to sea, our operations stopped until fuel supply was resumed.

For reasons like this, the armed forces are vitally concerned with the welfare of the oil industry in event of atomic attack. It is the mission of the Naval Radiological Defense Laboratory, San Francisco, California, to devise countermeasures and plan operating procedures in event of radiological attack. This information is disseminated to all military agencies, and through appropriate channels to the Federal Civil Defense Agency, which in turn passes it to the civilian community and to industry.

Effects

Before taking a look at the status of an oil refinery in the event of atomic attack, it is necessary to examine the basic effects of nuclear weapons. These effects are heat, blast, and radiation.

The first effect is instantaneous radiant heat, which burns exposed flesh and starts primary fires out to large distances. At the same time, there arises a strong flux of nuclear radiation, which is lethal for somewhat

EXCLUSIVE

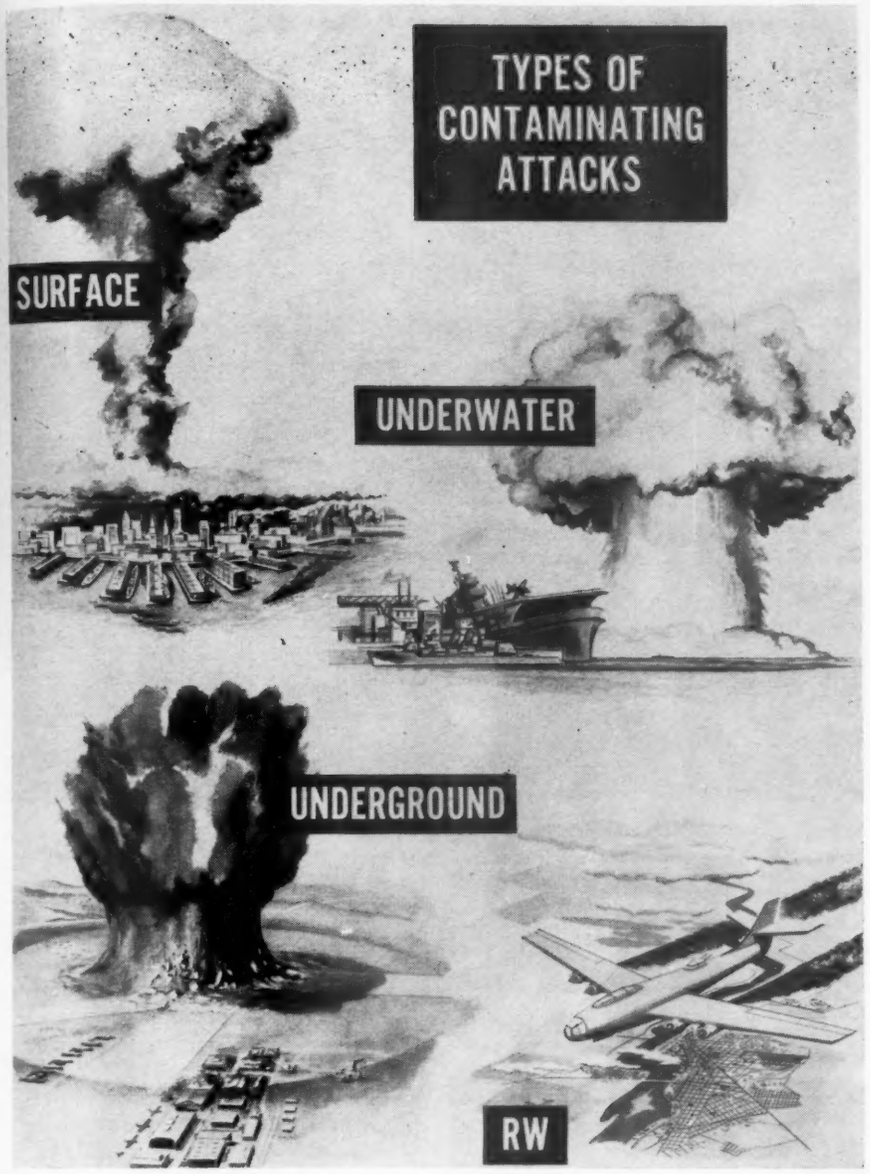

FIG. 3. Diagrammatic illustration of the types of contaminating attacks that must be guarded against.

shorter distances. Both of these last a relatively short time — up to several seconds for heat, about a minute for nuclear radiation. Next, starting concurrently but moving more slowly, at about the speed of sound, comes the powerful push of the blast wave. Finally, a radioactive cloud travels downwind from the point of explosion strewing out contaminant in its path. This contaminant takes minutes to hours to arrive, depending on the distance from the explosion. It is particularly important in a surface or subsurface detonation, in which cases it can be lethal to personnel who remain in the contaminated area.

Now to take up the net effect of these phenomena on an oil refinery. To avoid mentioning classified information, it is sufficient to say that the radius of practically total destruction can be a mile or more. We are interested in the situation at somewhat greater distances, where physical damage to structures ranges from severe to light. Visualize the time scale of events at this distance — instantaneous heat and so-called prompt radiation; then, seconds later, the blast pressure wave, and finally, minutes to hours later, the fallout of radioactive contaminant from the cloud. We shall consider them in this order.

First, heat. This heat can sear flesh and start fires in readily combustible materials. The kind of good housekeeping ordinarily practiced at a refinery should minimize the starting of fires by this heat flash, but exposed personnel will be burned. With the heat comes strong nuclear radiation lasting about a minute. This nuclear radiation can be lethal to unshielded persons, but has no effect on structures.

Next comes blast, which can knock down even solidly constructed buildings and above-ground storage tanks, perhaps start secondary fires where the heat flash did not, and block water and land approaches. However, the basic structures that comprise the heart of a refinery — fractionating towers and pipe lines — are highly resistant to blast because of their shape and can survive blast pressures that flatten buildings and storage tanks around them. The one important exception consists of the wooden cooling towers, which are very vulnerable to both heat and blast.

Finally, there may arrive the radioactive fallout from the cloud. This fallout can make large areas dangerous for continued occupancy and could well have the effect of shutting down a refinery which was out of range of the heat, prompt radiation, and blast.

Countermeasures

The first countermeasure to consider is warning, which would permit dispersion of personnel under cover and shielding, if available, and also the shutting down of those operations which might cause fires or explosions. Of course, there is the possibility of no warning at all, or of only enough warning to permit execution of simple pre-planned measures such as taking shelter, shutting valves, and banking fires, without time to carry out large scale dispersion of personnel.

Against the heat flash, the proper countermeasures are removal of flammable materials before attack and placing personnel under cover.

Against blast, the countermeasures to consider are:

(a) Sandbagging key control centers and small vital structures

(b) Evacuation of personnel from lightly constructed buildings into shelters

(c) Arrangements for the interchange of intermediate products with other refineries in order to by-pass damaged portions of the refinery flow pattern.

Against prompt nuclear radiation, only evacuation beforehand or else massive shielding is effective. Both should be used to prevent the situation in which the important components of the plant are lightly damaged or even intact but all the operating personnel are killed. First, careful arrangement of balanced working shifts should be made well in advance so that operating, management, and administrative personnel are more evenly divided among shifts around the clock. This should minimize loss of life, pro-

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FIG. 4. Damage from atomic explosion to a refinery of this type is incalculable; some structures are less vulnerable than others.

vided the off-shift personnel live at considerable distances from the plant in dispersed communities. From this standpoint, long-distance commuting should be encouraged. Secondly, consideration should be given to shielding small key control centers and building shielded shelters. About five feet of earth is good shielding. Thirdly, warning of attack should be the signal for those at the plant to go into shelters and notice to those away from the plant to *stay away* and *not* a signal to report to the plant.

Against the continuing effects of radioactive fallout, which may bar prompt resumption of operations, a number of countermeasures are possible:

(a) Shielding of key control centers, as was mentioned previously as a defense against heat, blast, and prompt nuclear radiation. A refinery lends itself fairly readily to remote control operation from a few key points.

(b) Careful scheduling of work shifts, especially for the maintenance and repair crews, to ration out their exposure to gamma radiation

(c) Decontamination of essential work areas by scrubbing or surface removal

(d) Use of protective clothing and respirators during debris clearance and decontamination to prevent deposit of radioactive material on and in the body

(e) For fractionating towers which may require repair, the use of a "washdown" system may be a simple method of decontamination. This consists of a set of water nozzles which place a film of flowing water over the structure *before* the fallout occurs.

FIG. 5. Appearance of the "cloud" following an atomic explosion above ground level.

Summary

Nuclear weapons have devasting effect through heat, blast, and nuclear radiation, but the physical plant of a refinery is for the most part resistant to such effects because of its normal dispersion and because of the shape of many of its vital structures. Its personnel, however, are much more vulnerable. With proper planning before attack, especially with attention to saving personnel, and concerted effort after attack, it is possible to resume at least partial operation reasonably soon after anything but a direct hit. If the latter is the case, the personnel saved by proper dispersion are still of vital importance to assist in the operation of other refineries which are not destroyed, but have sustained personnel casualties. * * *

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MECHANICAL ENGINEERING

The Choice, Design, Characteristics and Maintenance of Centrifugal Pumps

Part II

Development of design; multi-staging; performance or characteristic curves; changes affecting characteristic curves; effect of changes in liquid on performance

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CENTRIFUGAL pump designs may be classified as either special or commercial. Special designs are developed to meet one head-capacity condition with maximum efficiency. Pumps for city water supply, large irrigation or drainage projects are examples of special designs. Commercial designs are developed to meet a range of head, capacity and speed conditions with a minimum loss of initial design efficiency. Commercial designs must also provide for the maximum interchangeability of parts.

There is no elementary rule of thumb or equation applicable to either special or commercial designs. The elements that influence the development of details for commercial designs are hydraulic, mechanical, and metallurgical. The hydraulic design is concerned with head, capacity, speed and the physical characteristics of liquids. The mechanical design form must satisfy the requirements for both hydraulic and material efficiency. It must meet the restrictions of form and proportions imposed by the characteristics of the materials of construction without sacrifice of either structural strength or stability. The metallurgy is concerned with the temperature and the chemical properties of the liquid as well as the physical properties and corrosion resistance of the materials of construction. A major problem of the design engineer is to harmonize the requirements of the several elements, then translate them into a design that will be capable of broad application and be economical to produce and operate.

It is not practical to detail the mathematics of the steps in developing the design of a pump because of the variables and modifications possible in the form and proportions of various parts. For example, the design form of impeller vanes is influenced by the head, capacity, speed and form of the head curve. The magnitude of the losses through the impeller and the effect of the curvature of the vanes between the entrance and exit angles are difficult to interpret from either experimental or routine test data. Shock losses will vary with the direction and the rate of change in the velocity of the liquid leaving the impeller and entering the case.

In the development of impeller design the known factors are head, capacity, and speed. The unknown factors for which assumptions must be made are the inlet and outlet dimensions, the number, form, entrance and exit angles of the vanes, and the width of the passages through the impeller. The exit angle of the vane may be selected from 15 to 40 deg inclusive and the number of vanes 4, 6, 8, or in some cases, 10. The aim of the designer is to arrange the vanes so that the friction of the liquid along them shall be a minimum and that the velocity of the liquid leaving the impeller shall also be a minimum.

From the foregoing, it is evident that in developing commercial designs, the engineer must be free to combine theory with the knowledge of experience and in this case experience in his definition of his previous mistakes. Since it is impractical to reduce the theory-experience combination of each engineer to mathematical formulas, there will be differences in both the design details and performance characteristics of commercial pumps having the same size suction and discharge openings.

The nearest approach to what may be considered "rule of thumb" determination of impeller diameter and head

generation are:

$$D = \frac{1840C\sqrt{H}}{N} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$H = \left(\frac{DN}{1840C}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$N = \frac{1840C\sqrt{H}}{D} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$C = \frac{ND}{1840\sqrt{H}} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where

D = outside diameter of impeller
H = head in feet
N = speed in rpm
C = head coefficient at design point (point of maximum efficiency)

The value of C will vary with either or both the number of and the exit angle of the impeller vanes and because of these variations, there will be a range of values for any given head and capacity. The normal range of values for C is from 0.9 to 1.15 and the extreme 1.25. The average value for commercial designs is very close to 1.0.

The preceding equations will explain why pumps offered by different manufacturers for the same head-capacity-speed conditions may have impellers of different diameter, different form of head curve, shut-off head, and point of maximum efficiency.

To illustrate the possible differences in the diameter of an impeller designed for the same conditions, let us assume the design point to be 500 gpm, head 225 ft, speed 3550 rpm.

Case 1—Exit angle 25 deg; number of vanes 8; C = 1.0

$$\text{then } D = \frac{1840 \times 1.0 \times \sqrt{225}}{3550} = \frac{1840 \times 1.0 \times 15}{3550} = 7.77''$$

Case 2—Exit angle 18 deg; number of vanes 6; C = 1.1

$$\text{then } D = \frac{1840 \times 1.1 \times \sqrt{225}}{3550} = \frac{1840 \times 1.1 \times 15}{3550} = 8.55''$$

Case 3—Exit angle 30 deg; number of vanes 8; C = 0.95

$$\text{then } D = \frac{1840 \times 0.95 \times \sqrt{225}}{3550} =$$

$$\frac{1840 \times 0.95 \times 15}{3550} = 7.39''$$

Although the range of 7.39 in. to 8.55 in. is possible, in commercial practice the actual diameters would probably be confined within the limits of 7¾ to 8¾ in.

The head generated at the design point by impellers of the same diameter operating at the same speed will vary with either or both the exit angle and the number of vanes. To illustrate the difference in head generated at the design point, let us assume the impeller to be 10-in. in diameter and the speed 3550 rpm and the values of C the same as for the preceding examples. Then for,

Case 4—$H = \left(\frac{10 \times 3550}{1840 \times 1.0}\right)^2$
= 373 feet head where C = 1.0

Case 5—$H = \left(\frac{10 \times 3550}{1840 \times 1.1}\right)^2$
= 306 feet head where C = 1.1

Case 6—$H = \left(\frac{10 \times 3550}{1840 \times 0.95}\right)^2$
= 412 feet head where C = 0.95

FIG. 5. Volute type pump case, employed in nearly all single-stage designs.

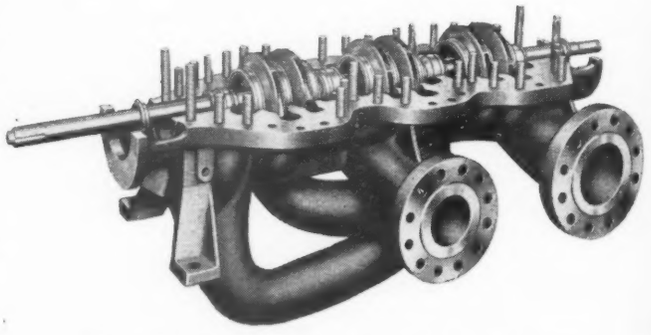


FIG. 6. Volute type case designed for multi-stage pumps, for 1000-1100 psig service.

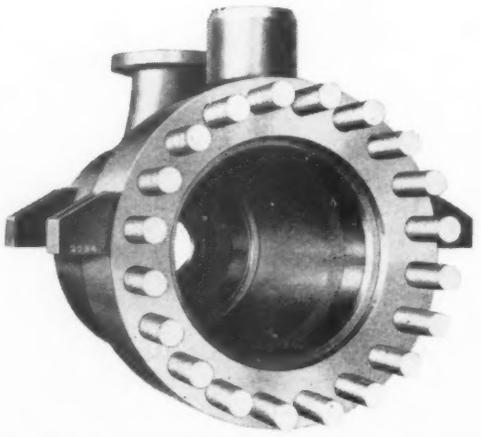


FIG. 7. The cylindrical case is preferred for 1100-1500 psig, a MUST for 1500 psig and higher.

Although the head generated at the design point may be varied approximately 34.6 per cent, the shut-off head will be practically the same in each case because shut-off head is a function of impller diameter.

The hydraulic functions of the pump case are to confine the liquid leaving the impeller, direct it to the discharge

nozzle and to provide the means for converting the kinetic energy in the liquid to potential or pressure energy. This direction and conversion must be as efficient as possible. The volute type case similar to Fig. 5, with modifications, is used for practically all single stage designs. The volute type case Fig. 6 may be used for multi-stage pumps for pressures to 1000 to 1100 psi. For pressures of 1000 to 1500 psi, the cylindrical case, Fig. 7, is preferred and for pressures above 1500 psi is considered a *must*.

Case and impeller design must be carefully coordinated for maximum efficiency; consequently, the mathematics of the theoretical hydraulic design become quite complicated. For commercial designs, we may assume that the quantity of liquid leaving the impeller is uniform about its periphery. We know the quantity flowing through the case will increase from A to B to C and become 100 per cent at D, Fig. 8. To prevent excessive velocities and friction losses in the case, the preliminary sectional areas at A-B-C and D are made 25-50-75 and 87.5 per cent of the sectional area of the discharge opening E. These areas are then adjusted to suit the final design. This gradual increase in sectional area reduces the velocity and the friction loss. To reduce shock losses, the angle of the tongue T is made as near as possible to the outlet angle of the water leaving the impeller.

The form of the cross section of the case at A-B-C and D, Fig. 8, may be circular or it may be the form shown by Fig. 9. The latter is preferred because the overall dimensions of the case are reduced without impairing its efficiency and the smaller case is more economical. The sectional area and velocity of flow through the discharge nozzle E varies with design capacity. For small capacities, the area may be proportioned for velocities of 20 to 30 ft per second, for large capacities, it may be proportioned for velocities of 8 to 18 ft per second.

The form of the single volute case, Fig. 8, causes an uneven distribution of pressure around the periphery of the impeller. In single stage pumps designed for high heads, especially the overhung impeller type with cantilever shaft, the unbalanced pressure may increase the shaft deflection and create an appreciable unbalanced load on the bearings. To obtain a more equal distribution of pressure and reduce the unbalanced load on the bearings, the double volute case, Fig. 10, was developed. The double volute design provides two similar flow channels with outlets 180 deg apart. These flow channels create opposing pressures of nearly equal magnitude about the periphery of the impeller and result in an appreciable reduction in the unbalanced radial loads on the shaft and bearings. The double volute case is now used by some manufacturers for all high pressure commercial designs above 2½-in. size.

The broad application of commercial sizes and the coordination of case and impeller design is shown by a pump having a 6-in. suction and 3-in. discharge. At 3550 rpm, the capacity range for this pump is from 425 to 800 gpm inclusive. The head range is from 150 ft minimum to 680 ft maximum. For the minimum condition, the pump would be furnished with a 7-in. diameter impeller and for the maximum condition a 13-in. diameter impeller. Obviously one case pattern could not be efficient for this range of impeller diameters. To provide the maximum efficiency and economy, three different case impeller combinations were designed. Case No. 1 is designed for impellers ranging from 7 to 9 in. in diameter; case No. 2 for impellers from 9 to 10½ in. and case No. 3 for impellers from 10 to 13 in. in diameter. This procedure enables the manufacturer to provide the most efficient and the most economic case-impeller combination for any head-capacity condition between the minimum and maximum for which a commercial design is developed. The purchaser receives the economic benefits of minimum first cost, maximum efficiency, and minimum cost for power.

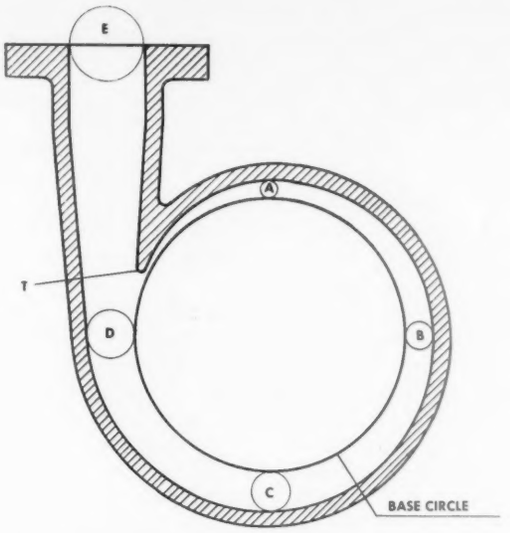


FIG. 8. Fundamental relationships of impeller and pump case; single volute case.

FIG. 9. Single-volute, (left), and double-volute types of cases.

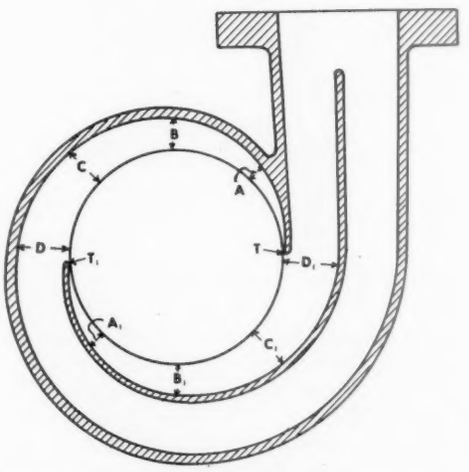


FIG. 10. Diagram of double-volute case showing the two flow channels around the periphery of the impeller. The pressure on each half of the impeller is nearly equalized by making the radial distance between impeller and case at points T-A-B-C-D identical with points T_1-A_1-B_1-C_1-D_1.

Multi-Staging

When two or more impellers act in series the heads are additive. For example, if three impellers each developing a head of 400 ft are arranged to operate in series, the total head developed will be 3 by 400 = 1200 ft. Multi-staging

may be effected in either of two ways. For moderate capacities, say up to 5000 gpm, two or more impellers may be mounted on the same shaft and arranged so they will act in series. For larger capacities, two or more single stage pumps may be arranged to operate in series.

The first or suction stage impeller for a multi-stage pump is most always designed specially for low NPSH characteristics. The impellers for the remaining stages are designed for head generating charactristics and have the same diameter. The impeller for each stage is designed the same as for a single stage pump.

The advantages of multi-staging are economic. The lower head per stage reduces the leakage loss between stages. The head developed by an impeller varies as the diameter squared and the disc friction varies approximately as the fifth power of the diameter; consequently, the use of smaller diameter impellers reduces the disc friction losses and increases the efficiency of the pump.

To illustrate the advantages of smaller diameter impellers for multi-stage pumps assume we are to design a pump for a total head of 4000 ft. If we make this in 10 stages, each impeller will develop $\frac{4000}{10} = 400$ ft head; if we make it 8 stages, each impeller will develop $\frac{4000}{8} = 500$ ft. Using a head co-efficient—1; by equation (6), the diameter of each impeller at 3550 rpm for 10 stages would be 10½ in. and for 8 stages, 11¾ in.

By Pfleiderer's equation, the hp loss from disc friction $(10) = 1.83 \left(\frac{U_2}{100}\right)^3 \left(\frac{D_2}{10}\right)^2$ where U_2 = the peripheral velocity of the impeller in feet per second and D_2 = the diameter of the impeller in inches.

For the 10½-in. diameter impeller $U_2 = 117$ and the disc friction hp $= 1.83 \left(\frac{117}{100}\right)^3 \left(\frac{10.5}{10}\right)^2 = 1.83 \times 1.61 \times 1.1 = 3.24$ hp or a total of $10 \times 3.24 = 32.4$ hp for 10 stages.

For the 11¾-in. diameter impeller $U_2 = 182$ and the disc friction hp $= 1.83 \left(\frac{182}{100}\right)^3 \left(\frac{11.75}{10}\right)^2 = 1.83 \times 6 \times 1.38 = 15.15$ hp or a total of $8 \times 15.15 = 121.2$ hp for 8 stages.

By using ten instead of eight stages, we reduce the hp lost in disc friction 121.2 — 32.4 = 88.8 or 73 per cent.

Multi-stage pumps for pressures up to and including 1000 psi may be furnished with an axial split case of either the volute type, or the diffuser type. This 1000 psi is not necessarily the top limit of the axial split case, but as the pressure increases above 1000 psi, it becomes more difficult to prevent leakage and erosion across the face of the axial joint. This is particularly true after a pump has been in service for sometime and has been dismantled for maintenance. For pressures above 1000 psi, the radial split, cylindrical case, with ring type joints is used. Some users prefer this type for pressures in the 800 to 1000 psi range, especially if operating temperatures of 250 F and above are involved, because its symmetrical form renders it free from distortion as a result of temperature changes. A cylindrical case may be a steel casting for pressures up to 1500 psi. The heavier metal sections required for higher pressures, make it difficult to secure sound castings free from porosity. For pressures above 1500 psi, the cylindrical case is fabricated from a steel forging, to insure strength and freedom from porosity under all pressure-temperature conditions. Here again we find some users who prefer the forged to the cast case for pressures below 1500 psi because it insures maximum freedom from material defects.

In a multi-stage pump furnished with a cylindrical case, the kinetic energy in the liquid leaving the impeller is converted to potential energy in a diffuser surrounding each impeller. The diffuser may be either the twin volute type or the multiple vane type.

The twin volute diffuser is in effect two volute passages with tongues 180 deg apart. To insure efficient conversion, the outside diameter of the volute type diffuser must be relatively large. This adds to the size and cost of the pump case. Twin volute diffusers should be installed so that the volute tongues in one stage are 90 deg from the tongues in the adjoining stage. If the volutes are not staggered, there may be an appreciable radial hydraulic unbalance.

FIG. 11. The vane type diffuser, with multiple vanes equally spaced is preferred for multi-stage, cylindrical case pumps.

The vane type diffuser, Fig. 11, with multiple vanes equally spaced is the preferred type. The vanes are designed to form liquid passages of gradually expanding area to insure a uniform decrease in velocity from the inlet to the outlet. The liquid passage can be thoroughly cleaned and smoothed to insure the most efficient conversion of energy. The multiple passages equalize the pressure at all points about the periphery of the impeller resulting in perfect radial hydraulic balance.

The liquid leaving the diffuser and entering the passage leading to the next impeller has both a radial and a tangential component. If not properly guided, the flow through the passage would be spiral and the liquid would enter the eye of the next stage impeller tangential to the direction of the impeller rotation. This would cause an appreciable loss in the efficiency of the pump. To prevent this loss, guide vanes are cast in the passages between stages to properly direct the flow and cause the liquid to enter the eye of the impeller radially.

The inlet angle of the diffuser vane is made the same as the angle of the liquid leaving the impeller. The number of vanes is varied to meet the needs of the capacity for which the pump is designed. To avoid possible noisy operation, the number of vanes in the diffuser may be more or less but not the same as the number of vanes in the impeller. The details of the vane form are determined more by experience and the results of tests than by formulas. The outside diameter of the diffuser is proportioned to provide liquid pas-

sages of sufficient length for the efficient conversion of kinetic to potential energy.

The radial clearance between the outside diameter of the impeller and the bore of the diffuser is a variable. It is some function of the peripheral speed of the impeller and the capacity and the actual clearance is determined more by experience of the design engineer rather than by formulas.

The mechanical design of parts such as the shaft and sleeve type bearings follows established practice. The equations for torque, flexure, and other details of shaft design will be found in any standard reference book. The permissible loading and speed together with the limitations for ball and roller bearings are published by the manufacturer.

Performance or Characteristic Curves

The performance of a centrifugal pump is affected to a marked degree by its design details, especially those of its impeller. The actual performance of the completed design is established by testing the pump from zero to maximum capacity. The results of the test, when plotted on coordinate paper, form a number of curves each of which shows graphically its part of the performance of the pump. These curves are known as "characteristic curves," "performance curves" or simply "the curves" of the pump.

The characteristic curves show the changing relationship between head, capacity, efficiency, brake horsepower, and NPSH corresponding to variations in one or more of these factors. By the law of homologous design, pumps of the same type fitted with impellers of similar design, will have characteristic curves of the same shape. This makes it possible to predict with reasonable accuracy, the changes that will occur within the operating range of an impeller.

The four characteristic curves usually shown and the identification of each as shown by Fig. 12 are:

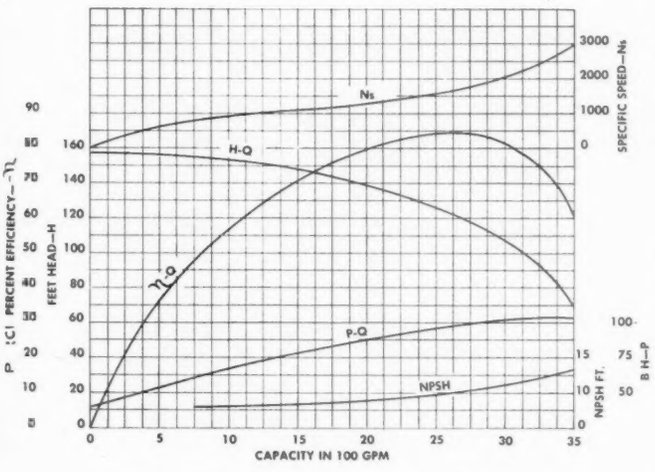


FIG. 12. Four characteristic curves for centrifugal pumps.

Head—marked H-Q or simply, head.
Efficiency—marked N-Q or simply, efficiency.
Brake horsepower—marked P-Q, or simply bhp.
Required net positive suction head—marked NPSH.

The Head Curve

Head curves may be divided into flat, drooping, rising, steep, stable and unstable depending upon their shape. The influence of the form of the impeller vanes upon the shape of the head curve is shown by Fig. 13. The design point for each impeller is 100 per cent capacity and head.

Flat curves, 1 and 2, show little variation in head for all

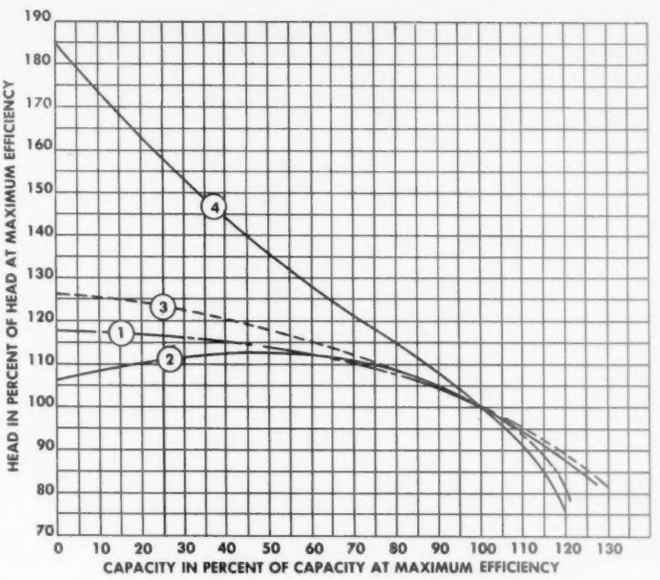


FIG. 13. Influence of impeller vane form on the shape of the pump head curve.

capacities between the design point and shut-off. A flat curve may be either a rising curve 1, or a drooping curve 2.

A drooping curve, sometimes called a looping curve is one for which the head developed at shut-off is less than the head developed at some capacities between shut-off and the design point. See curve 2.

A rising curve as its name implies is one for which the head developed increases continuously as the capacity decreases from the design point to shut-off. See curves 1-3-4.

A steep curve is one for which there is a large increase between the head developed at the design point and that developed at shut-off. Curve 4, is a steep curve.

A stable curve is a rising curve such as 1-3-4, for which there is but one capacity for any one head.

An unstable curve is one for which the same head can be developed at more than one capacity. Basically this is a drooping curve, 2.

The Horsepower Curve

Brake horsepower or P-Q curves may be designated as overloading or non-overloading depending upon the design of the impeller.

Overloading curves can be either of two types... One type, as shown by Fig. 14, has a low bhp requirement at

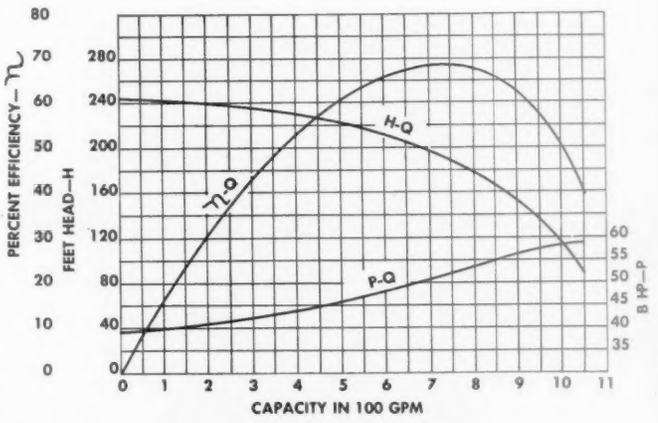


FIG. 14. One type of overloading curve, having low BHP requirement at shut-off, and constant increase with a decrease in head, and an increase in capacity.

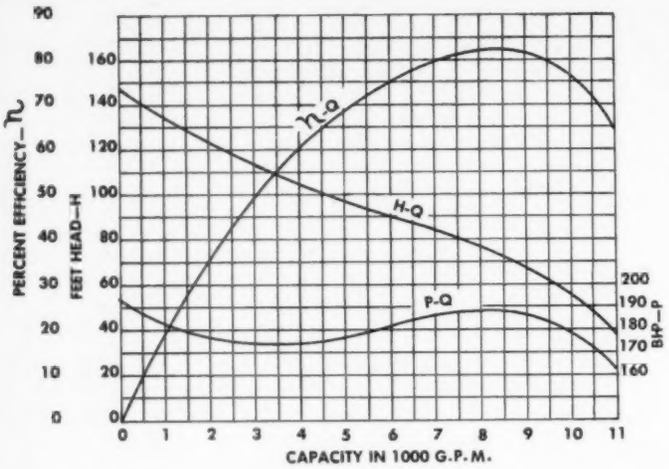


FIG. 15. Overloading curve with low BHP requirement at minimum head and maximum capacity, and increases as capacity decreases, becoming maximum at shut-off.

shut-off and a constant increase with a decrease in head and an increase in capacity. The other type shown by Fig. 15, has a low bhp requirement at minimum head and maximum capacity and increases as the capacity decreases and becomes maximum at shut-off.

A non-overloading curve is shown by Fig. 12. Curves of this type have a low bhp at shut-off. As the capacity increases, the bhp increases to a maximum, then flattens out and decreases as the capacity increases beyond the point of maximum efficiency.

The NPSH Curve

The NPSH curve, Fig. 12, shows the net positive suction head required for each capacity for a pump furnished with a given impeller.

Specific Speed Curve

The specific speed of an impeller is a function of the capacity and head developed at a given rotative speed and will vary from zero at shut-off to infinity at maximum capacity and zero head. The Ns curve, Fig. 12, is added to show this variation from shut-off to a point beyond maximum efficiency. After passing the point of maximum efficiency, the specific speed increases rapidly as the capacity increases and the head decreases. This Ns curve shows why the specific speed of an impeller at any other than the point of maximum efficiency must not be used as an index of the impeller type.

Changes Affecting Characteristic Curves

Unless otherwise stated, the characteristic curves submitted by the pump manufacturer will show the performance of the pump for one diameter impeller, one speed and one liquid. These curves will be affected by a change in either the diameter of the impeller or the speed and they may be altered to an appreciable extent by a change in the liquid pumped.

A change in the diameter of the impeller will at constant speed change:

1—the capacity in the direct ratio of the diameter.

2—the head in the ratio of the diameter squared.

3—the bhp in the ratio of the diameter cubed.

A change in speed only will change:

4—the capacity in the direct ratio of the speed.

5—the head in the ratio of the speed squared.

6—the bhp in the ratio of the speed cubed.

The mathematical equations for these changes not only include two unknowns, but that for capacity is a direct ratio while that for the head is the ratio squared. Because of these differences, the impeller or speed change necessary to effect a change in capacity—head conditions is first determined by "trial and error." These results are then checked by applying the equations:

$$\text{Capacity} — Q \quad \frac{D_1}{D} Q \text{ or } Q_1 = \frac{N_1}{N} Q \quad . \quad . \quad . \quad (11)$$

$$\text{Head} — H_1 = \left(\frac{D_1}{D}\right)^2 H \text{ or } H_1 = \left(\frac{N_1}{N}\right) H \quad . \quad . \quad . \quad (12)$$

$$\text{Bhp} — P_1 = \left(\frac{D_1}{D}\right)^3 P \text{ or } P_1 = \left(\frac{N_1}{N}\right)^3 P \quad . \quad . \quad . \quad (13)$$

Where

D = diameter of present impeller
D_1 = diameter of changed impeller
H = head in ft present impeller
H_1 = head in ft changed impeller
N = rpm present conditions
N_1 = rpm changed conditions
P = bhp present diameter impeller or present rpm
P_1 = bhp changed diameter impeller or changed rpm
Q = capacity gpm present impeller or present rpm
Q_1 = capacity gpm changed impeller or changed rpm

The characteristic curves for the operating range of a pump fitted with an impeller 10½ in. in diameter and operating at 3550 rpm are shown by Fig. 16. The original design point was 700 gpm; head 395 ft; specific gravity of

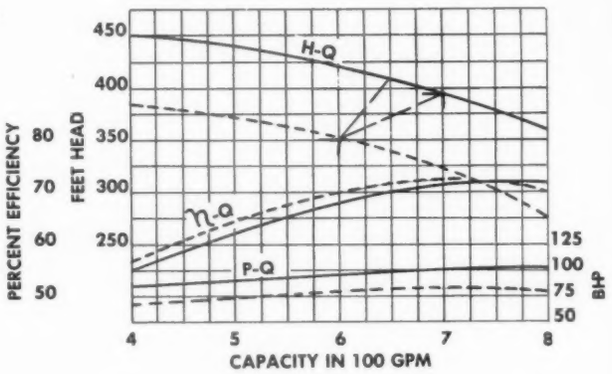


FIG. 16. Characteristic curves for a pump with 10½-inch diameter impeller operating at 3550 RPM.

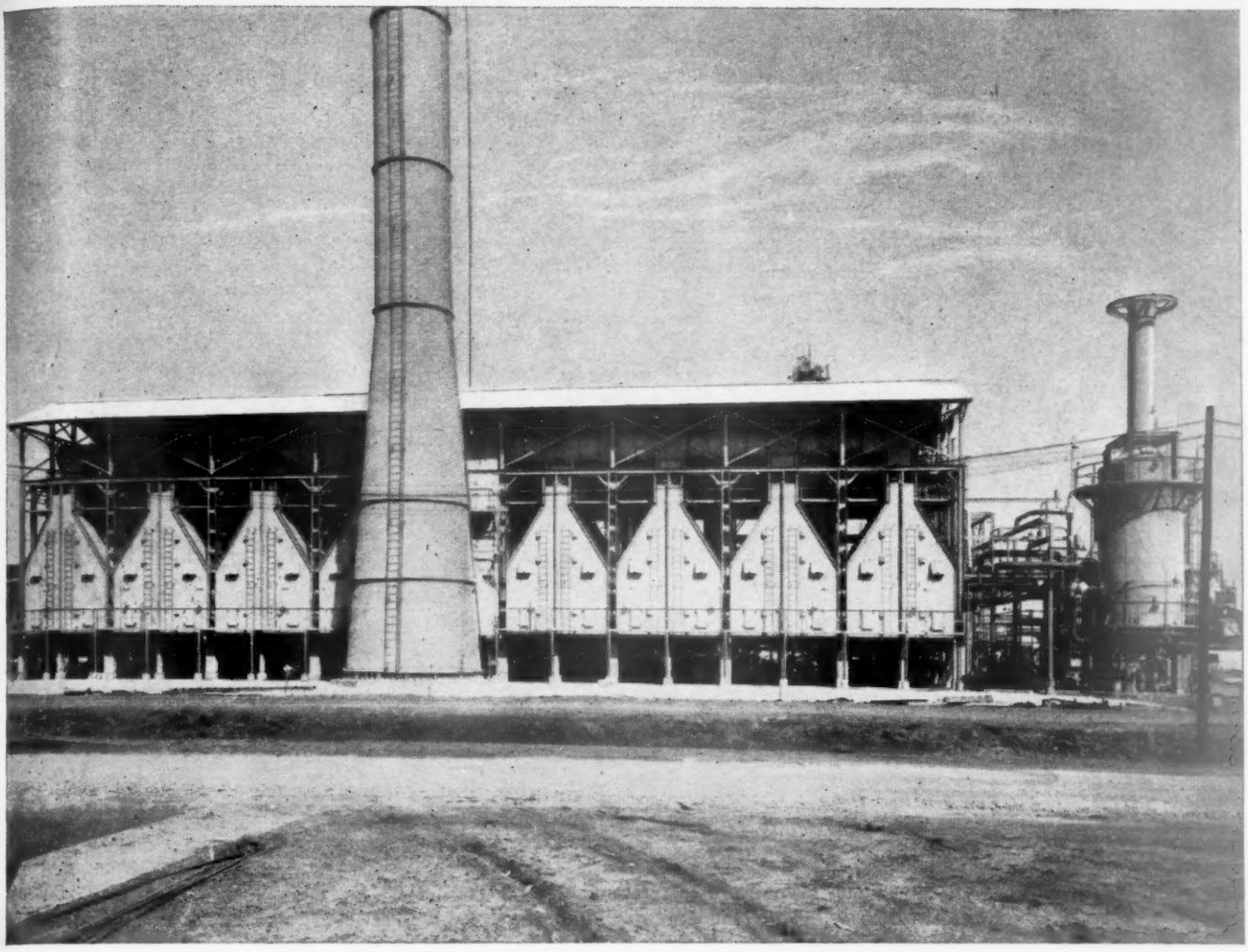
liquid 1.0; efficiency 71.5 per cent; bhp 98. It is desired to reduce the capacity to 600 gpm and the head to 350 ft. To determine the impeller cut for this new condition by "trial and error": First—using the 700 gpm and 395 ft head as a starting point we have—

$$D_1 = \frac{Q_1}{Q} D = \frac{600}{700} \times 10.5 = 9 \text{ in. dia. for capacity.} \quad (14)$$

and

$$D_1 = \sqrt{\frac{H_1}{H}} D = \sqrt{\frac{350}{395}} \times 10.5 = 9.8 \text{ in. dia. for head} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

The required capacity could be obtained with the 9-in. impeller, but it would not develop the required 350 ft head. Next try a point of lower capacity and higher head at the left of the original condition point.



200 million pounds of Ethylene can be produced yearly by this bank of eight ethane cracking furnaces at the Tuscola, Illinois plant of National Petro-Chemicals Corporation, (a joint enterprise of National Distillers Products Corporation and Panhandle Eastern Pipeline Company). Largest single installation of its kind to date, these furnaces, operating above 1500F°., produce ethylene by cracking ethane in Incoloy tubes.

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Second—try the 650 gpm—410 ft head point. We then have

$$D_1 = \frac{Q_1}{Q} D = \frac{650}{700} \times 10.5 = 9.75 \text{ in. for capacity and}$$

$$D_1 = \sqrt{\frac{H_1}{H}} D = \sqrt{\frac{350}{410}} \times 10.5 = 9.7 \text{ in. for head.}$$

The 9.75-in. diameter impeller will give both the capacity and head required. In practice the impeller would be cut to 9¾-in. diameter. The performance would then be:

$$\text{Capacity} — Q_1 = \frac{D_1}{D} Q = \frac{9.75}{10.5} \times 650 = 604 \text{ gpm and}$$

$$\text{Head} — H_1 = \left(\frac{D_1}{D}\right)^2 H = \left(\frac{9.75}{10.5}\right)^2 \times 410 = 354 \text{ ft}$$

The efficiency at 650 gpm and 410 ft is 70 per cent and this point would move to the left to 600 gpm. The bhp (equation 17) would be $\frac{604 \times 354 \times 1.0}{3960 \times .70} = 77.1$ bhp

or $P_1 = \left(\frac{D_1}{D}\right) P = \left(\frac{9.75}{10.5}\right)^3 \times 96 = 77$ bhp.

If desired, the performance of the 9¾ in. impeller can be calculated for several points and the characteristic curves plotted as shown by the dotted lines on Fig. 16.

The capacity-head changes corresponding to speed changes are calculated exactly the same as for changes in impeller diameter.

Limit of Impeller and Speed Changes

Practically all types of impellers for commercial pumps are designed for a maximum diameter and with a suitable provision for reducing to a predetermined minimum. Reducing the diameter of any impeller causes some variation in the exit angle of the vanes and in the width between the shrouds. Since these variations will not be the same for all types of impellers, some may be reduced to a minimum diameter equal to 75 per cent of the design maximum while others may be limited to a reduction equal to 85 to 90 per cent of their maximum.

If the permissible minimum diameter of an impeller is not shown by either the characteristic curve or the data sheet for the pump, that impeller should not be cut, without first consulting the manufacturer. Reducing the diameter beyond the design minimum will render the impeller useless.

There are no particular problems in connection with speed reduction because both capacity and head are reduced with the speed. Increasing the speed may introduce some problems because the maximum speed may be limited either by the design, the materials of construction or whether rotating parts are dynamically balanced. Some commercial designs are limited to 2000 to 2200 rpm, others may be operated safely at speeds up to 4000 rpm. At the present time, standard designs with rotating parts fabricated from alloy steels are in commercial operation at speeds ranging from 7200 upward to 10,000 rpm.

Effects of Changes in Liquid Upon Performance

By reason of their effect upon the performance of a centrifugal pump, two physical characteristics of liquids are of primary importance, especially to the pump user. The first is viscosity, the second is the gravity of the liquid.

A detailed discussion of viscosity and its effect upon performance would be too long to include here. A brief discussion will emphasize its importance, however. Viscosity is the resistance that the particles of a liquid offer to sliding past each other. It varies greatly from one liquid to another and decreases with an increase in the temperature of the liquid. If the viscosity is low, the particles slide easily as in water, gasoline, and similar liquids. If the viscosity is high, the particles do not slide easily, as in asphalt base crudes and heavy fuel oils.

The performance guarantee for a pump is based on water. When the viscosity of a liquid exceeds that of water, all friction losses in the pump increase, causing a loss in head, capacity and efficiency and an increase in the bhp required for driving the pump. For example if the liquid pumped should be 1000 SSU, the head would be reduced approximately 5 per cent; the capacity 7 per cent and the efficiency 20 points below the performance with water. The bhp would be increased 28 per cent above the bhp for water. These values would increase for viscosities above 1000 SSU and decrease for viscosities below 1000 SSU.

The gravity of the liquid to be pumped is of primary importance because it affects the discharge head, the diameter of the impeller and the bhp for driving the pump. To illustrate the effects of gravity, we will assume a pump is installed to deliver 500 gpm of liquid having a specific gravity of 0.75 against a discharge pressure of 110 psi when operating at 3550 rpm.

The head for which the impeller would be selected is found from the equation

$$H = \frac{2.31 \times \text{psi}}{\text{sp gr}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

and for our problem we have $\frac{2.31 \times 110}{0.75} = 339$ ft head.

An impeller approximately 10 in. in diameter would be selected to develop this head at 3550 rpm and the HQ performance curve is based on results of tests with this impeller. A change in the gravity of the liquid pumped will not change the points on this HQ curve because the head developed is fixed by the speed, the diameter, and other design details of the impeller.

The gravity of the liquid pumped affects the bhp required for driving the pump because it is a factor in the ft lb of work to be done. This is shown by the equation

$$\text{bhp} = \frac{\text{GPM} \times \text{H} \times \text{Sp Gr}}{3960 \times \text{Pump Eff.}} \quad . \quad . \quad . \quad . \quad (17)$$

where

gpm = capacity in gallons per minute.
H = head in feet of liquid.

Assuming an efficiency of 70 per cent, our pump would require

$$\frac{500 \times 339 \times 0.75}{3960 \times .70} = 45.9 \text{ bhp}$$

for driving. Since the head remains constant at 339 ft, a change in the gravity of the liquid pumped will increase or decrease the bhp in direct ratio of the increase or decrease of the gravity. For example, if the specific gravity of the liquid is increased from 0.75 to 1.0, the bhp becomes $\frac{500 \times 339 \times 1.0}{3960 \times .70} = 61.2$ or 33 per cent above that required for the lighter liquid. If the gravity is decreased to 0.60 the bhp would decrease 20 per cent from 45.9 to 36.7.

In nearly all cases, the pump and driver are selected and installed to handle one liquid. If a change is contemplated, the viscosity and gravity of the new liquid should be carefully checked to determine their effect, if any, on the performance of the pump and the bhp of the driver.

End Part 2

Part 3 will appear in an early issue.—Ed.

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DISTILLATION

Methods for Fractionating Crude Oil

Part V

V. A. Kalichevsky

Magnolia Petroleum Company

WHEN crude oil is heated in a flask, it vaporizes rapidly. These vapors may be cooled by passing them through a condenser which, in its simplest form, is a tube surrounded with cold water. As the temperature in the flask rises, vapors flowing through the condenser turn into liquid. This liquid can be collected in a receiver, a temporary storage vessel for the products.

At first the liquid that condensed is colorless. Then it acquires a light straw yellow color that gradually deepens into the shades of brown as the process continues. A point is reached when the brown-black liquid remaining in the flask begins to decompose under the influence of heat. This process is commonly known as distillation. Products collected on distilling crude oil show no abrupt changes in their properties.

If extremely elaborate equipment is employed, however, temperature variations proceed in steps. First the temperature remains constant for a certain length of time. Then it rises rapidly to another temperature level where it stays approximately constant for a while before making the next jump. Each one of these abrupt changes indicates the presence of a separate hydrocarbon.

As distillation proceeds, temperature fluctuations become more difficult to detect until finally they disappear. This shows that the heavier oil fractions contain a very large number of individual hydrocarbons, each present in negligible quantities, which makes their isolation practically impossible. For this reason only the lowest-boiling hydrocarbons are separated at the refineries in a comparatively pure state. The remaining portions of crude oil are collected according to their boiling ranges. Fractional distillation is used in order to secure the sharpest possible separation between the individual fractions which are reworked into marketable products.

Pipe Stills

Distillation is carried out in huge stills that have been developed to a high degree of perfection. Several days are required for starting such equipment and attaining the desired distillation conditions; but once the plant is started, it will operate for months and even years before it is shut down for cleaning or repairs.

A modern still is shown schematically in Fig. 2. It consists of a furnace, a fractionating tower, condensers and receivers from which the oil is transferred to storage. The crude oil is pumped under pressure through pipe coils located in the furnace and heated by flame or by hot combustion gases. The flow of crude oil through the coils is very fast in order to avoid decomposition of the oil at the high temperature prevailing in the furnace.

After leaving the furnace, the hot crude oil is released into a flash chamber within the fractionating tower. The flash chamber is an empty space below or between the fractionating plates. As the pressure in this chamber is considerably lower than in the pipe coils, most of the crude oil vaporizes, or "flashes" into the free space. The resulting vapors move up the fractionating tower by condensing and re-evaporating at each successive fractionating plate, as will be described later in connection with the fractionation of natural gasoline.

Fractionation is improved by cooling the top of the fractionator. This is done usually by returning some of the distillate to the top plate in the column. It increases the quantity of liquid or reflux flowing down the column. The petroleum vapors have to work through this additional quantity of liquid in their upward travel. This increases the sharpness of separation between the petroleum fractions as effected by the same number of plates in a column. Cooling at the top requires larger condensers, however. It also requires more heat at the bottom of the fractionator to force the vapors to the top of the column. This additional energy applied to both ends of the system is expensive. The height of the column must be balanced, therefore, against the quantity of reflux needed to obtain the desired results.

The unevaporated portion ("heavy ends") of the crude oil flows from the flash chamber toward the still bottom in a direction opposite to the rising vapors. On their way they encounter a number of fractionating plates that help to strip them from the light fractions they still may contain. To facilitate stripping, steam may be passed into the

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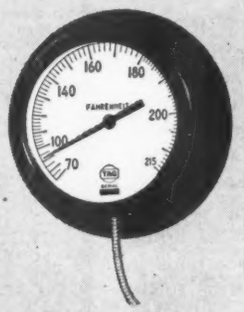

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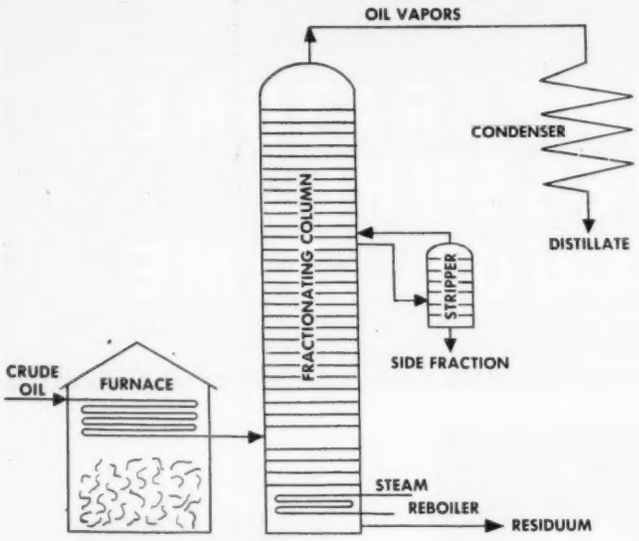

FIG. 1. Simplified diagram of a modern crude still.

tower, and the bottom of the still may be equipped with a reboiler, i.e. with heating coils that supply additional heat to the oil bottoms before they leave the system. The presence of steam insures evaporation of petroleum fractions at temperatures lower than those that would be required in its absence. Low distillation temperatures are desirable for protecting the oil from overheating which may result in decomposition.

The number of fractionating plates in a tower may vary within wide limits. Usually about 20 to 30 plates are located above the flashing chamber. When fractions boiling within a very narrow range must be separated, the number of the plates may be raised to 50 or 60 and even more. Such conditions are encountered, for instance, in the preparation of iso-pentane from natural gasoline. The height of the fractionating column depends on the number of plates it contains and attempts were made to reduce it by splitting the column into two sections standing side-by-side on the ground. Vapors from the first section are fed to the bottom of the second section through well insulated pipes. Similar provisions are made for feeding reflux from the bottom of the second section to the top of the first. The number of fractionating (stripping) plates below the flash chamber is seldom more than six.

Fractionating Plate

Fractionating plates vary in design. They must provide an efficient contact betwen the liquid and the vapor without offering excessive resistance to their passage through the tower. This is a difficult engineering problem to solve.

Efficient contact requires intimate mixing. Power must be used to obtain it. Consumption of power is reflected in the pressure drop through each plate. On these plates vapors are forced to pass through small openings and the bubbles thus formed must rise through a layer of liquid for insuring the interchange between the hydrocarbons in liquid and vapor states. Pressures in a fractionating tower are, therefore, higher at the top than at the bottom where the oil originally vaporizes. As the boiling temperature rises with pressure, the oil must be heated to a higher temperature in the fractionating tower than in an open vessel before it starts boiling. This means that the high-boiling oil fractions may decompose under the influence of heat before they distill over.

A diagram of a conventional fractionating plate is shown in Figure 2. Vapors from the plate below pass through a riser into the bubble cap which has slots or openings at the bottom. These slots are below the surface of the liquid. Gas bubbles are formed that rise through the liquid. During their passage through the liquid the heavy hydrocarbons in the vapor condense and liquefy, giving off heat. This heat is picked up by the low-boiling hydrocarbons in the liquid which thus are vaporized and join the vapor stream. After passing through each plate the percentage of the low-boiling hydrocarbons in the vapors increases and that of the high-boiling hydrocarbons decreases. The greater the number of plates, the better is the separation of the low-boiling hydrocarbons in the vapors from the high-boiling hydrocarbons in the liquid.

The liquid level at each plate is maintained by adjusting its height by means of a weir. This weir is a miniature dam. The liquid from the upper plate overflows the weir into the downcomer or the downspout leading to the plate below. The downcomer is a pipe with its lower end immersed into the liquid at the lower plate. This is necessary as otherwise vapors would displace the liquid in the downcomer by following the path of least resistance and thus by-pass the bubble caps.

Numerous designs of bubble caps were worked out and new ones still appear from time to time. These caps must be constructed so as to provide maximum mixing of vapors and liquid at a minimum loss of pressure across the fractionating plates. Caps differ in the size and shape of the holes and in other features. Some of the caps are like inverted troughs extending all across the plate. Not all of the designs are equally effective and the plate efficiencies are compared with respect to a "theoretical plate" where the exchange between the hydrocarbons in the vapor and liquid phases reaches an ultimate balance, i.e. when the composition of the vapors and that of the liquid are in equilibrium.

The vapors leaving the top of the fractionating tower are liquefied by passing them through condensers. Condensers must have a large cooling surface in order to condense vapors into liquid. The heavy liquid from the bottom of the fractionating tower, known as residuum, is removed continuously from the still. This completes separation of the oil charge into a light and a heavy fraction, or "overhead" and "bottoms" respectively.

The actual design of commercial stills is more complicated than the above simplified description. The oil charged to the fractionating tower may be separated into more

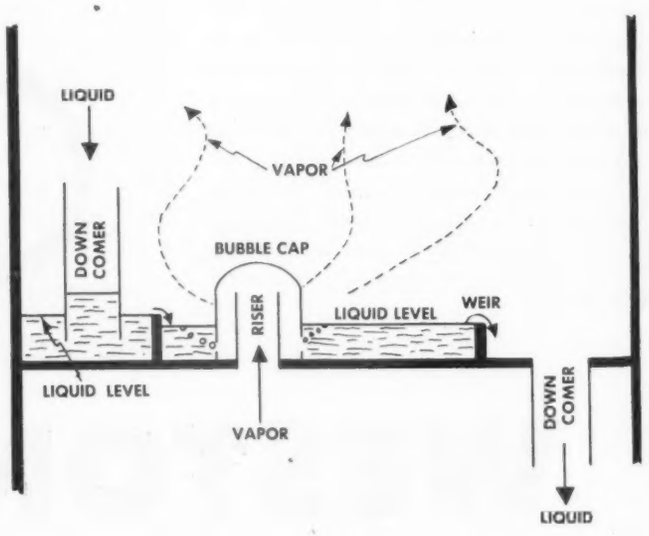

FIG. 2. Detailed drawing of a typical bubble tray.

than two fractions by using additional equipment. This is done by removing from the tower some of the liquids condensed on the intermediate fractionating plates. The liquid from one of the plates is transferred into a separate vessel attached to the fractionating tower where it is heated (stripped) to boil off all the lighter materials it may contain. Vapors given off during this "stripping" operation are returned to the fractionating tower at a place where they would interfere as little as possible with the preparation of other fractions, usually on a tray just above where the stream was drawn off. The stripped liquid portion is removed from the system for further processing. Five or six fractions having different properties may thus be prepared at once from one column.

Fuel Consumption

Considerable attention is paid to the conservation of fuel which is an appreciable item in the plant economy. This is done by employing a large number of heat exchangers which take away heat from the oil streams leaving the still and transfer this heat back to the incoming still charge. In these exchangers the two oil streams are separated from each other by walls made of metals that are good conductors of heat. The oil to be heated is passed in the opposite direction to the oil to be cooled. In this counterflow method of contact the oil entering the still is preheated to a maximum possible temperature because just before leaving the exchanger it is in contact with the hot oil flowing directly from the still into the exchanger.

This and other improvements in still design resulted in enormous savings in the cost of fuel required to distill the crude oil. The average consumption of fuel per barrel of crude oil distilled is now less than half of that consumed in 1925. Modern refining processes require the expenditure of tremendous quantities of heat for reworking the crude oil into the high-grade products. Even under these unfavorable conditions, however, the overall consumption of fuel by the refineries decreased 25 per cent over the same period of time (1925-1955).

Pipe stills are a relatively recent development. Before they were adopted by the petroleum industry, the so-called shell stills were used. The shell stills were of simple construction but they consumed much fuel and required a much longer time to bring the oil to the distillation temperature. Shell stills are still used when the quantities of materials handled are small and when the fuel economy is of secondary importance, however.

Shell Stills

The design of shell stills is simple. They consist of a large cylindrical steel vessel which is charged with the oil to be distilled. The fire is started in the firebox under the still and, after the oil begins to boil, the oil vapors are passed through the fractionating tower and condensers into the receivers. The boiling point of these fractions rises as distillation progresses and the fractions of the desired boiling range are collected by changing the receivers. By comparing the two types of stills it may be observed that the pipe still operates continuously while operation of the shell still is intermittent, or "batch." For the same reason the products obtained from the pipe still are each of a uniform boiling range, while those obtained from the shell still are not. But a shell still can be operated continuously, simulating the pipe still operation.

Oil can be charged to the shell still in a continuous stream and an equivalent volume of bottom pumped away to give room for the fresh charge. The composition of the oil in the still and that of the vapors thus stay about constant. If several shell stills are interconnected, forming a "still battery," the bottoms from one still may serve as the feed to the next still of the series. With this arrangement each still produces a continuous stream of a uniform product, although separation of light and heavier fractions is less satisfactory than in a pipe still. The fuel consumption is high because the system of heat interchangers cannot be as elaborate as in a pipe still. Shell still batteries were widely used during the early stages of pipe still development, because they permitted a relatively efficient utilization of obsolete equipment.

FIG. 3. Typical double-column vacuum still for producing largely lubricating fractions, with mainly gas oil overhead; heaters not shown.

Heat Exchange

The oil is brought to distillation temperature by applying heat directly to the metal tubes or still shells containing the oil. Gas, oil, or coal are employed as the sources of heat, depending on the cost of these commodities. This direct application of heat may result in local overheating of the oil above the safe limits. For this reason processes were developed for transferring heat to the oil in an indirect manner and thus eliminate the danger of overheating.

In these processes an auxiliary heat-stable substance, a "thermofore," is heated directly with the flame. The hot thermofore is then circulated through heat exchangers where the heat is given off to the oil. As the oil cannot be heated above the temperature of the thermofore, the danger of overheating the oil is eliminated. The auxiliary heating medium circulates in a completely enclosed system and its mechanical losses due to leakage are reduced to a minimum.

The simplest thermofore is steam, which is used by the refineries for transferring moderate quantities of heat to

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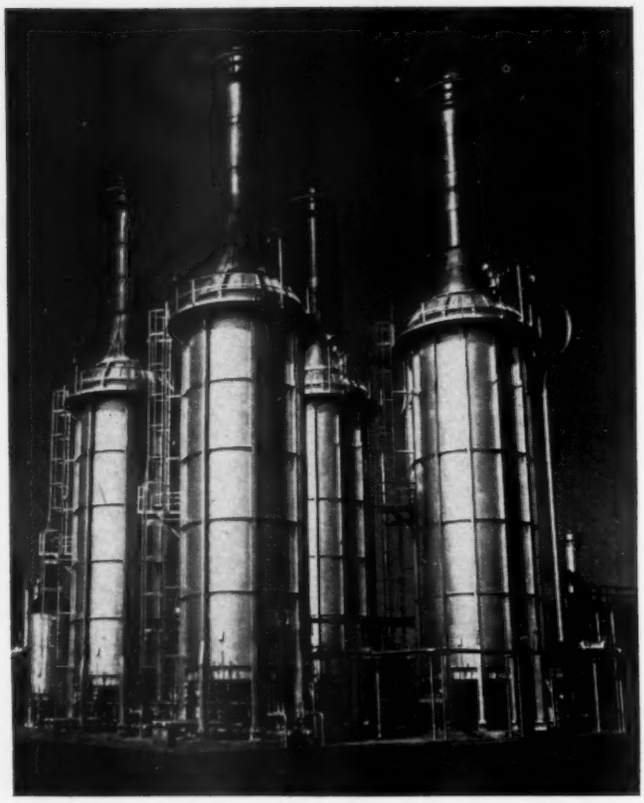

FIG. 4A. Cylindrical tube still with vertical tube banks inside the furnaces.

the oil. The only difference between steam and other thermofores is that water is easily available and its conservation is not as important as that of the expensive chemicals. Several commercial processes employing thermofores other than water were developed. The Mercury Process uses mercury, the Dowtherm Process employs diphenyl oxide, a stable organic material. Other processes employ mixtures of inorganic salts. Of these mixtures the one containing sodium and potassium nitrates and nitrites is the best known.

The nature of the heating medium has no relation to the quality of the products obtained in processing because the heating medium and the oil are never brought into direct contact. The choice between individual thermofores is one of economy, provided their physical and chemical characteristics are satisfactory for the purpose they must serve.

With the exception of steam, thermofores are seldom used by the refiner. Local overheating in pipe stills can be avoided by increasing the rate of oil flow. A fast flowing stream of oil creates much turbulence and none of the oil is left for a long time in direct contact with the hot metal walls of the tubes through which the oil flows. Likewise the time required for heating the oil to a high temperature is shortened by raising the furnace temperature and increasing the rate of oil flow still higher. Under these conditions the oil is heated quickly to very high temperatures and time is too short for the decomposition reactions to develop to any appreciable extent.

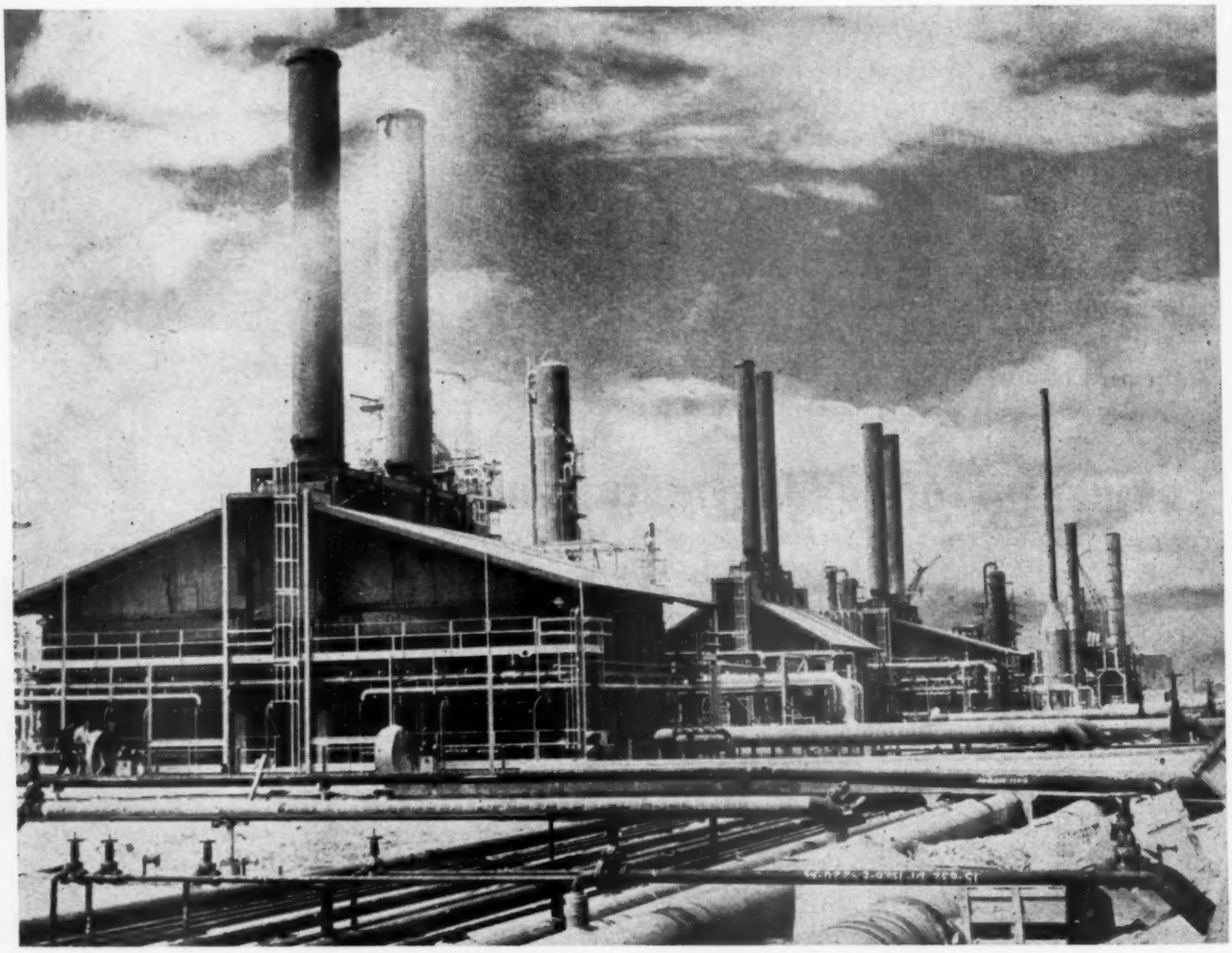

FIG. 4B. Box type crude stills, of general rectangular cross-section.

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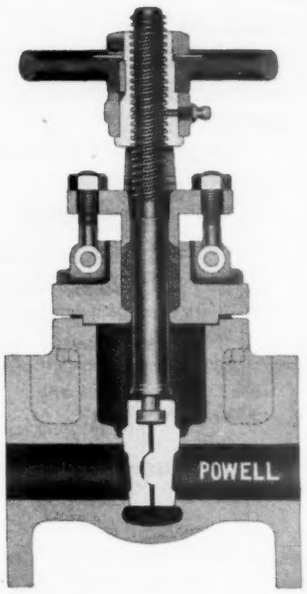

FIG. 2495 (Sectional)—Stainless Steel O. S. & Y. Gate Valve for 150 Pounds W. P. Double Wedge Disc is accurately guided to seat.

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FIG. 375—Bronze Gate Valve for 200 Pounds W. S. P.

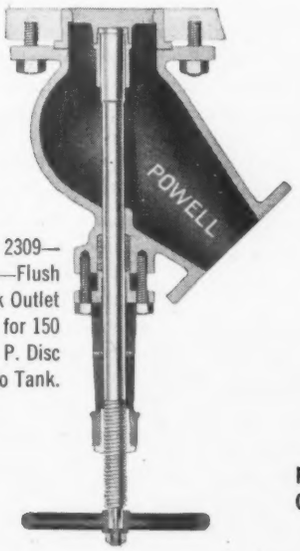


FIG. 2309—(Sectional)—Flush Bottom Tank Outlet Valve for 150 Pounds W. P. Disc Opens Into Tank.

FIG. 2193—Large Ni-Resist* Gate Valve for 200 Pounds W. O. G.

*Trade-mark of The International Nickel Co.

POWELL VALVES

Vacuum Distillation

Light fractions distill from the oil at temperatures below those at which the oil decomposes. Complications arise in distilling the high-boiling fractions which require high temperature for their vaporization, however. When the crude oil is reworked into fuels, slight decomposition due to high still temperatures is of little importance, but in the production of lubricating oils it may damage seriously the quality of products.

Heating the oil to the high temperatures needed for distilling the heavy fractions can be avoided by using vacuum. The boiling temperature is directly related to the pressure under which the oil is distilled. The oil boils at the temperature at which the pressure of its vapors exceeds the pressure of the surrounding atmosphere. If this outside pressure is reduced, the temperature at which the oil boils is lowered. For this reason the boiling temperature of the heavy oil fractions is lowered if vacuum is applied to the still. For instance, if an oil boils at 750 F at standard atmospheric pressure, which is 760 mm mercury (Hg), it will boil at 470 F if this pressure is reduced to 10 mm Hg, and at 390 F if the pressure is reduced to 1 mm Hg.

In the manufacture of lubricating oils the crude oil is distilled in two stages, first at atmospheric pressure and then under vacuum. Two stills are used for this purpose. In the "atmospheric still," bottoms known as "long residuum" are obtained. This long residuum which contains the heavy oil fractions is transferred into the "vacuum still" where distillation continues. In addition to applying vacuum, large quantities of steam are blown through the oil in order to reduce the distillation temperature still more. Bottoms obtained from vacuum distillation is known as "short residuum."

The main concern of the refiner is to make as much product as he can at the minimum expense. Distillation cannot be done cheaply in one operation. At least two "stages" are necessary to make it economical. Sugar industry uses three, four, even five stages for distilling off water from sugar liquor to meet competition. These stages are quite distinct with respect to pressure applied, but the intricate system of heat exchangers make them look as one unit. In the petroleum industry only two stages, *atmospheric* and *vacuum*, are employed. Wording is simple but it does not convey the real meaning of the two stages.

The dividing line between the atmospheric and vacuum steps is not pressure, but consumption of power. Pressure or vacuum, steam, may be used in *atmospheric* distillation depending on economics. Close calculations must be done for establishing the conditions under which a still should be run to show profit.

Distillation Products

In distilling crude oil for the recovery of light products and fuel oils, the refiner obtains the "straight-run" gasoline, kerosine, and gas oil. Residuum is withdrawn from the bottom of the fractionating tower and used as fuel or reworked into asphalt if it is suitable for this purpose. In distilling crude oil for the recovery of lubricating oils, the refiner obtains straight-run gasoline and kerosine from the atmospheric tower and largely lubricating oils from the vacuum tower. A small quantity of gas oil boiling between kerosine and the lightest of the lubriacting-oil fractions may be recovered also. The number and physical characteristics of the lubricating-oil fractions depend on the type of finished products desired and of course on the nature of the crude oil from which they are distilled.

In this description it is assumed that the fractions or "cuts" are collected in a definite order and that there is no overlap in the boiling ranges of the manufactured products. Actually many refinery products contain common fractions boiling within the same temperature ranges. This is shown in Table 7 and Fig. 5.

TABLE 7. Boiling ranges of Petroleum products.

Product	Approximate boiling range, F
Liquefied gas	— 48 to + 34
Petroleum ether	+ 86 to +140
Aviation gasoline	+ 90 to +300
Aviation gasoline	+ 90 to +410
Jet propulsion fuel	+100 to +550
Precipitation naphtha	+122 to +266
Painters' naphtha	+210 to +325
Stoddard solvent (cleaners' naphtha)	+300 to +400
Kerosine	+350 to +550
Fuel oil (gas oil)	+400 to +600
Refinery gas oil	+400 to +750
Mineral seal oil	+500 to +675
Transformer oil	+550 to +750

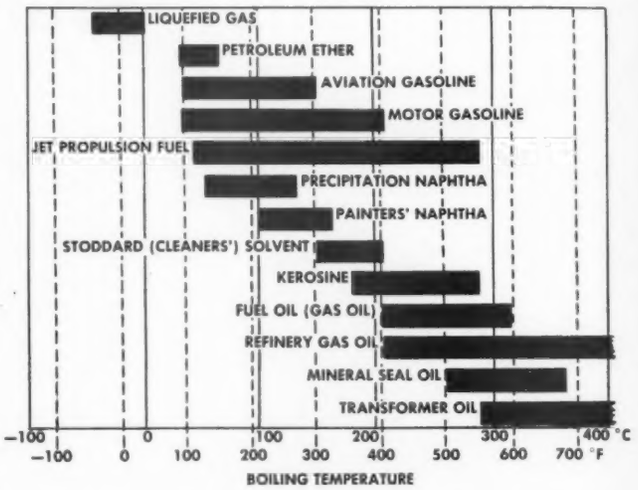


FIG. 5. Boiling range chart for various refined products, showing how the ranges overlap.

Distillation ranges of lubricating oil are not included in the table because they are distilled under vacuum and their boiling temperatures at atmospheric pressure are uncertain. Besides lubricating-oil fractions are prepared not to meet boiling point, but viscosity, flash point, and other specifications.

In preparing products of different boiling ranges the refiner adjusts the temperature width of the fractions so that they can be used for blending into products sold by the refinery. If the refinery is interested in aviation gasoline, redistillations can be avoided by breaking motor gasoline into two fractions: the aviation gasoline fraction and a fraction somewhat resembling the cleaners' solvent fraction. Then motor gasoline is obtained by blending these two fractions in proper proportions. If crude oil contains excessive quantities of kerosine, some of the kerosine can be left in the gas oil. Such variations in refinery operations are numerous and they change with the market demand. If small quantities of materials boiling within narrow ranges are needed, however, they are obtained by redistilling broader fractions in small shell or "steam" stills. Pipe stills are not economical unless large volumes of products are prepared.

The above shows that considerable skill is required in planning and timing the plant operations. Highly trained technical personnel are needed to tackle scientific problems which the refinery has to meet. For this reason many companies choose their plant personnel from the research and development staff in order to be abreast of modern developments.

End — Part V

High heat value, low volatile matter, and low ash content make coke a good kiln fuel

Satisfactory Burning of Fluid Coke

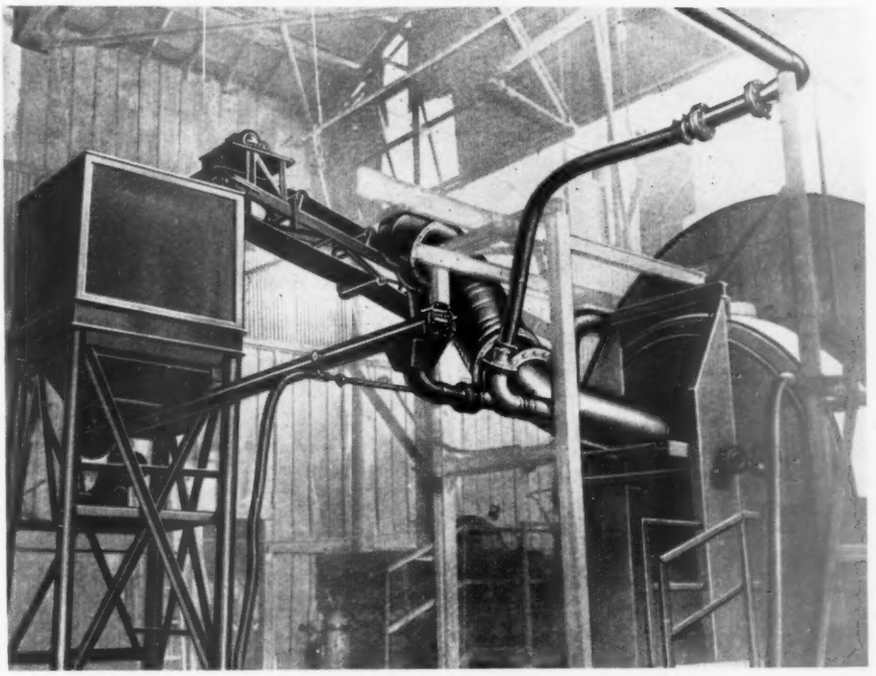
R. M. Cornforth and Edward R. Lee Jr.
Kaiser Engineers Division of Henry J. Kaiser Company

HISTORICALLY, the petroleum refining industry has been faced with the problem of reducing the percentage yield of residual fuel oil based on crude oil. Since it is the only major petroleum product selling for less than the cost of crude oil, there exists a considerable economic incentive for reducing the yield of residual fuel oil with an accompanying increase in lighter products. The total annual demand for residual fuel oil in the United States has remained substantially constant during the period 1950 to 1953, and showed a reduction of about 7 per cent in 1954. During this time, the demand for gasoline and light products has been steadily increasing. Forecasts indicate that this trend toward a reduction in residual fuel oil and an increase in lighter products will continue.

The refining industry has utilized various processing methods for reducing the percentage yield of residual fuel oil, including visbreaking, vacuum distillation, propane deasphalting, and delayed coking. All of these methods have been used not only in the reduction of residual fuel oil yield but also in the increase of gas-oil suitable as charge stock for catalytic cracking. This in turn has increased the production of high octane gasoline and distillate fuel oils to meet the changing market requirements.

In August, 1953, the new fluid coking process, developed to produce a maximum reduction in residual fuel oil yield was announced by its licensor, Esso Research and Engineering Company. The first commercial application of this continuous process was installed by the Carter Oil Company at its Billings, Montana, refinery, where a 3800 bbl per day fluid coker went on stream in late 1954. In comparison with the earlier delayed coking process, fluid coking produces about twice the yield of gas-oil, which can be cracked to high octane gasoline and only about half the yield of coke.

The by-product coke produced by the fluid coking process is a new industrial material in the form of a dry, hard, granular solid having roughly the particle size of coarse sand. It is composed of approximately 90 per cent carbon, with the other constituents varying considerably depending upon the source of the crude.



Kiln and special fuel system employed to study the burning of fluid petroleum coke.

From the standpoint of the petroleum refining industry, the problem is not in the facilities for the production of fluid coke but rather in the development of suitable markets that will utilize the potential of this material. A substantial amount of research and development work directed at new market applications for fluid coke has been and is being carried on by different groups in several fields of industry. Although it is likely that some high value usages can be developed such as carbon electrodes for use in the electrolytic reduction of alumina to aluminum, it appears that the ultimate base load for this material will be as a fuel. In this use, it should have wide application because of its high heating value, low volatile matter, and low ash content and because it can be produced in large quantities at widely separated refinery locations. It has already been successfully burned in a rotary kiln and is equally adaptable for use in oil heaters and boiler installations.

Kaiser Engineers with the assistance of Permanente Cement Company has studied the application of fluid coke as an industrial fuel. The first cycle of this investigative program was completed when full scale combustion tests were conducted in rotary kiln operations at the Permanente, California, plant of the Permanente Cement Company.

A 50-ton sample of fluid coke was obtained in March of this year for test purposes from the Carter Oil Company's new coking unit at Billings. This coke was shipped from Billings to Permanente in a closed, railroad hopper car of the type used to transport bulk cement. The car was spotted and unloaded over a conventional track hop-

EXCLUSIVE

per. An open dump truck was used to transfer the material to the test site.

The analysis of this sample as received is as follows:

Screen analysis		Composition	
Screen size	Cumulative per cent retained		Weight per cent
8	5.2	Carbon	89.1
35	11.1	Sulfur	6.0
65	48.6	Volatile (1742 F)	3.8
100	80.1	Ash	0.16
200	95.8	Vanadium	0.03
		Nickel	0.01
		Net heating value Btu/lb	14,300

At Permanente, there are five rotating kilns that are among the largest in the cement industry. These kilns are 450 ft long, 12 ft in diameter, and are inclined at ½-in. per foot. The average speed of rotation is 57 rph, with an average clinker capacity of 4000 bbl per day each.

These kilns are normally fired with natural gas purchased from the local utility at an average of 948,000 cu ft per hour. During the one or two extremely cold months each year, Bunker C fuel oil is used. Fuel is admitted to the kiln by a burner that extends 8 ft into the discharge end of the kiln. The burning zone begins approximately 15 ft from the hood and is about 50 ft long. Primary air for combustion is provided by 75-hp fans. It is in the combustion zone, where the temperature reaches 2900 F, that the majority of kiln reactions occur. The back end or feed-end temperature of the kiln is approximately 700 F.

Of the five kilns at Permanente, kiln No. 1 was selected for the fluid coke testing primarily due to its ease of access and adjacent space for setting up test equipment. Surplus material and equipment around the plant were used wherever possible. Because of the high plant production schedule, it was not possible to shut down the kiln either to make modifications in the burner arrangement or to assist in the actual tests. This requirement made mandatory the use of existing 4-in. diameter oil-burner housing and adapting it to handling coke in a high-velocity air stream.

The fluid coke was transferred from the open dump truck to a 7-ton elevated bin adjacent to the kiln by means of a bucket elevator. To this bin was fitted a hopper bottom that connected directly to a 6-in. screw conveyor pipe. The conveyor screw was driven by a vari-drive unit with a speed range of 4 to 1. Coke discharging from this conveyor was aspirated by compressed air through the special burner into the kiln. A maximum of 6¾ tons of coke per hour could be handled with this arrangement through the 4-in. burner port.

Preliminary runs were made on March 17, 18, and 22, 1955, burning the raw fluid coke as received without screening or grinding. The maximum firing used during these tests was about 3½ tons per hour delivered to the kiln, with natural gas furnishing the balance of a necessary heat input. During these runs, each of which was about two hours duration, a dropout of large particles of unburned coke was observed that were later found in the analyzed test clinker.

These preliminary tests suggested the potentialities of fluid coke as a fuel. Because of the dropout of the larger particles, some of which were approximately ⅜ in. in diameter, it was decided that the coke should be ground to a more uniform size for subsequent testing. Accordingly, about 10 tons of the coke were ground, having the following screen analysis:

Screen analysis	Cumulative per cent retained
16	0
50	1.0
65	11.0
80	20.1
100	50.3
200	75.5

Weight of ground material: Tamped, 63.4 lb/cu ft
Loose, 55.7 lb/cu ft

The methods developed by Kaiser Engineers lead us to believe that on a commercial basis this grinding can be done for less than 30 cents per ton.

A preliminary run with the ground coke was made on May 5, 1955. With the input of primary air for coke combustion at 600 cfm and 80 psi and with 50 per cent natural gas as the auxiliary fuel, the color, shape of the flame, lack of fallout, and ignition 10 ft beyond the nozzle indicated a performance almost identical with 100 per cent gas flame. This was followed on May 18 with a commercial, scale demonstration under similar conditions that was witnessed by representatives of oil companies and other large industrial firms. The limited supply of ground coke available permitted only a brief demonstration. The 14,000 lb of coke in the hopper was consumed in 1.2 hr. The maximum firing rate of 13,500 lb/hr was attained after a rapid build-up of coke flow, during which time the gas was reduced accordingly. Auxiliary firing of gas in reduced quantities was necessary to maintain input heat balance, but for several intervals of short duration the gas was turned off permitting the kiln to operate entirely on coke. The normal, natural gas fuel consumption of this kiln is approximately 212 mcf/hr with 1100 btu cu ft gas or 233,200,000 btu/hr. Since the heating value of coke is 14,300 btu/lb, about 17 per cent of the normal gas flow was required to maintain the kiln temperatures.

Sampling devices and other test equipment were set up well in advance of this demonstration in order to obtain the maximum amount of information during the test. Other than the temperature checks within the kiln itself, the sampling and testing were accomplished at both ends of the kiln, of the clinkers for any significant change in composition and of the effluent gases for any significant change of analyses, particularly with respect to sulfur.

During the test, the kiln temperatures rose from approximately 2680 F to about 2800 F and the back end or gas-outlet end of the kiln rose from

The Authors

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R. M. (Bob) Cornforth has been in engineering construction and process licensing sales for most of his professional career since graduating from the University of Tennessee with a BS and receiving an MS from Massachusetts Institute of Technology, in chemical engineering. Prior to World War II, he was in process design, cost studies and economic evaluation work with Standard Oil Company (Indiana). For three years, he was secretary of various committees in the Petroleum Administration for War in Washington, D. C., and New York City and was special assistant to the directors of refining and of foreign refining, with the rank of lieutenant colonel in the U. S. Army Corps of Engineers. Since 1945, he has been sales engineer and sales director for Houdry Process Corporation, vice president in charge of sales for W. M. Barnes Company, plant engineers and constructors on the West Coast. In 1954 he became manager of refinery sales for his present company, Kaiser Engineers division of Henry J. Kaiser Company. He is a member of American Institute of Chemical Engineers, California Natural Gasoline Association, and American Petroleum Institute.

Edward R. Lee, Jr., attended Rensselaer Polytechnic Institute, the University of Michigan, and the graduate school of the University of Michigan receiving BS, ME, and MS degrees. He is a registered professional engineer in the states of New Jersey and Michigan. He belongs to the National Professional Engineers Society, American Society of Mechanical Engineers and the Engineers Club of New York City. Lee has more than twenty years experience in the steam power field in design, construction, and operation of power generating facilities. In recent years, he has been a consulting engineer on numerous steam power plant projects for several of the country's large public utility companies.

Avoid **gel-clogged** *fuel line complaints with Du Pont Metal Deactivator*

A rash of complaints due to clogged fuel lines causes headaches among fuel oil refiners and marketers during any heating season. And, as you might expect, the fuel oil is often blamed for causing the trouble.

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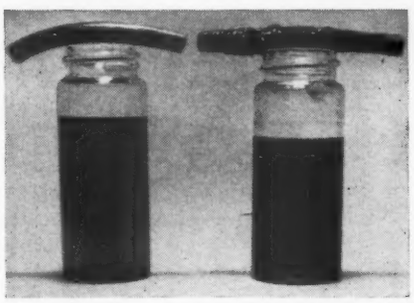
Since the feed-in line and the screen are often made of copper, they are a potential source of copper mercaptides which, if formed in sufficient quantities, become gelatinous in nature. You can assure better customer relations by protecting your oil against this gel formation with Du Pont Metal Deactivator in addition to Fuel Oil Additive No. 2, which guards against sludge.



Left, fuel and copper tubing stored for two weeks with 0.05 wt. % mixed mercaptans and 0.1 theory of Metal Deactivator. Right, fuel and copper tubing stored for two weeks with 0.05 wt. % mixed mercaptans without Metal Deactivator.

Low-cost insurance

In most fuel oil stocks, Du Pont Metal Deactivator is highly effective in low concentrations (about 2 pounds per 1000 barrels). This means that you can adequately insure yourself against the harmful effects of copper and promote better customer relations at a cost of less than ½ cent per barrel.

Du Pont Metal Deactivator was originally developed to prevent copper from accelerating harmful gum formation in gasolines. It also has valuable application in kerosines, diesel fuels, turbine oils and jet fuels.

A booklet describing the properties, uses, and methods of addition of Du Pont Metal Deactivator is available. If you do not already have a copy, ask any of our representatives or regional offices listed below to send you one.

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680 F to 705 F. The uptake draft was kept constant at 2 in. of water.

Samples of clinker were taken during the run, which were analyzed as follows:

	Control	Test
SO_3	0.027%	0.034%
Free CaO	0.120	0.060
Ignition loss	0.090	0.000

The laboratory advised that these clinker samples appeared normal and analyzed as such.

The bulk of the sampling and testing was conducted at the back end of the kiln, directed toward analyzing the kiln effluent with particular reference to the sulfur content and its accompanying dangers of air pollution. An iso-kinetic probe, similar to a pitot tube, was used to take centerline gas and dust samples. The gas samples were analyzed by a Mine Safety Appliance Company H_2S detector, essentially a glass tube with a reagent coating of silver cyanide on aluminum oxide granules. The concentration of H_2S determined by four tests of the MSA detector showed 0.0003 per cent by volume on a dry-gas basis.

A paper thimble was used to collect effluent dust. Sulfur compounds in the dust are in the form of both sulfate (calcium sulfate) at 16 per cent and sulfite (sodium potassium sulfite) at 84 per cent. Based on a rate flow of 34.4 tons per day and corrected for the control run, the analysis ran 0.97 per cent S and was equivalent to 27.4 lb per hour of sulfur.

The total sulfur in the gas (H_2S and SO_2), collected in a Na_2CO_3 solution and condenser water computed at 185,000 cfm at 480 F and corrected for the control run, was determined to be 33.2 lb per hour. It was concluded from the test that the SO_2 in the gases of combustion reacts with the alkaline in the slurry feed, resulting in the appearance of sulfur compounds both in the clinker and the dust particles collected by the precipitators.

From the test data and observations, it would appear that if all five kilns of this plant were operating wholly on fluid coke, the total sulfur released to the atmosphere would probably be on the safe side, or not objectionable, assuming there is a 50-50 split of the sulfur being found in the stack gases and in the dust collected by the precipitators. The amount of sulfur found in the clinker was insignificant. Any reduction of the total coke burned or a reduction of sulfur below the 6 per cent analysis of this sample would minimize the air pollution problem.

It may be concluded that fluid coke is a fuel that with proper handling and design of facilities can be burned with good combustion characteristics. ★ ★

Ethyl Corporation

Slight Gain in Octane Numbers

Gasoline on sale at service stations in August showed a nationwide weighted average of 95.9 octane number for premium and of 88.5 octane number for regular, according to the latest monthly survey by Ethyl Corporation.

Premium gasoline was 0.1 octane number higher than its corresponding July average while regular gasoline was unchanged. Compared with August 1954, premium gasoline was 2 octane numbers higher and regular gasoline was 1.6 octane numbers higher.

Average tetraethyl lead contents in August were 2.59 ml per gallon of premium gasoline and 2.27 ml per gallon of regular gasoline.

Twenty-seven of the 53 cities in Ethyl's survey reported increases over July in the average octane number of their premium gasolines, with 10 of these cities gaining 0.5 octane number or more. In regular gasoline, 24 cities had a higher average antiknock quality than in July, with 8 showing a gain of 0.5 octane number or more.

Compared with the nationwide premium average of 95.9 octane number, 15 cities reported premium averages of 96.5 octane number or higher. In regular gasoline, 16 cities showed average octane ratings of 89 octane number or higher, compared with the national weighted average of 88.5 octane number.

Average research octane numbers.

	Premium Gasoline		Regular Gasoline	
	Aug. 1955	July 1955	Aug. 1955	July 1955
Albuquerque, N. M.	95.1	94.1	84.9	84.2
Amarillo, Texas	95.5	95.4	86.4	86.6
Atlanta, Georgia	97.0	97.1	88.5	88.5
Bakersfield, Calif.	95.3	94.7	85.6	85.5
Baltimore, Md.	96.6	96.7	90.2	90.2
Billings, Mont.	93.5	93.5	86.0	86.3
Birmingham, Ala.	96.8	97.1	88.7	89.2
Boston, Mass.	96.9	96.7	90.5	90.4
Buffalo, N. Y.	96.4	96.6	90.2	90.4
Casper, Wyo.	92.0	92.1	84.9	85.0
Central Michigan	94.4	94.6	87.9	88.3
Charlotte, N. C.	97.0	96.9	88.5	88.9
Chicago, Ill.	95.1	95.0	88.2	87.9
Cincinnati, Ohio	95.8	95.6	90.3	90.0
Cleveland, Ohio	94.8	95.0	89.9	89.7
Corpus Christi, Texas	97.3	96.6	88.0	87.7
Dallas-Fort Worth, Texas	96.4	95.9	87.3	87.0
Denver, Colo.	90.9	91.0	83.5	84.0
Detroit, Mich.	94.9	94.7	89.6	89.3
El Paso, Texas	95.0	93.7	84.5	83.6
Fargo, N. D.	93.4	93.4	86.3	86.1
Hartford, Conn.	96.6	96.6	90.5	90.3
Houston, Texas	95.9	96.0	87.1	86.7
Indianapolis, Ind.	94.7	95.0	89.1	89.1
Jackson, Miss.	96.9	96.7	88.7	88.9
Jacksonville, Fla.	96.5	96.6	89.7	89.7
Kansas City, Mo.	93.9	94.2	86.1	86.3
Little Rock, Ark.	96.9	96.2	88.7	88.5
Los Angeles, Calif.	95.4	95.3	85.7	85.1
Louisville, Ky.	96.1	96.3	88.7	88.9
Memphis, Tenn.	96.6	96.9	88.4	89.4
Metropolitan N. Y., N. J.	96.9	96.5	90.6	90.2
Milwaukee, Wis.	95.2	94.9	89.0	88.3
Minneapolis-St. Paul, Minn.	94.4	94.1	86.1	86.4
New Orleans, La.	96.3	96.7	88.5	88.7
Northwest Pennsylvania	94.6	94.7	89.8	89.6
Oklahoma City, Okla.	94.1	94.1	86.2	86.2
Omaha, Neb.	94.0	94.0	86.1	86.5
Philadelphia, Pa.	96.5	96.8	90.2	90.6
Phoenix, Ariz.	96.2	95.2	87.0	85.8
Pittsburgh, Pa.	96.7	96.7	90.5	90.4
Portland, Ore.	95.6	95.4	86.6	85.6
Richmond, Va.	96.7	96.8	90.1	90.1
Salt Lake City, Utah	91.6	90.8	82.4	82.4
San Antonio, Texas	96.2	95.7	87.7	86.8
San Francisco, Calif.	95.8	95.8	85.8	86.1
Seattle, Wash.	95.0	94.9	86.2	85.8
Shreveport, La.	96.3	95.4	87.7	87.7
Spokane, Wash.	95.0	94.7	85.6	86.0
St. Louis, Mo.	94.1	94.0	86.7	86.2
Toledo, Ohio	94.9	95.2	89.4	89.7
Tulsa, Okla.	93.9	93.5	85.7	85.9
Wichita, Kans.	94.0	93.7	86.2	86.2

What are front- and heavy-end tails, overlaps and gaps, side refluxes and internal strippers?

BASIC TECHNIQUES IN PETROLEUM FRACTIONATION

C. H. Brooks

FRACTIONATION techniques in the petroleum industry are based upon the same fundamental laws that are used for all distillation operations. Because of certain special requirements that arise in the oil industry, however, different techniques have been developed. They have not yet, in most cases, been reduced to a rigorous theoretical treatment. Therefore, the design of most of the equipment that will be covered in this paper is on a purely empirical basis. Certain relations have been developed by experience and have been found to work.

Due to the complexity of the problems in the operation, it has been impossible so far to develop a sound theoretical basis for them. Analogies have been drawn to the more theoretical approach applicable when there are two, three, or at most, four components in the mixture to be separated. By contrast, there may be dozens to hundreds of individual compounds in the mixture to be separated in a petroleum fractionator.

Distillation or fractionation in the petroleum industry differs only in a minor degree from the same operation as performed in the chemical industry. The differences are really more apparent than real. There are certain modifications of the basic process that are quite different, however. In addition, the size of the equipment that is used in some cases is very much larger in the petroleum industry.

*Given at the Experience in Industry Symposium, "Distillation in Practice," A. I. Ch. E. and University of Pennsylvania. This symposium is to be published in book form by Reinhold Publishing Company.

Distilling a Liquid Product

One of the important differences in distillation as practiced in these two portions of the process industries is the use of equipment that produces a distilled, but liquid, product from the distillation equipment. The traditional distillation operation has a fractionating column such as shown in Fig. 1 which has the feed introduced somewhere in the middle section, takes an overhead product and a bottoms product that comes directly or indirectly from a reboiler. The reboiler provides vapor to permit the fractionating process to proceed.

In the petroleum industry a considerable portion of the distillation equipment carries the same "fractionating tower." A simple version of the fractionating tower is shown in Fig. 2. It will be noted in this tower that it is divided into two sections, Section A and Section B. The top and bottom of the tower are similar to the conventional fractionating column as shown in Fig. 1. In the center section of the tower, however, there is a "chimney" with annular trays around it. From the bottom annular tray there is withdrawn a side stream product. Open steam is also introduced on this tray.

In the mid part of Section A of the tower, vapor enters the tower at tray F_A. Liquid that runs down over the annular trays, counter-current to a stream of vapor, consists mainly of steam. In the top part of this section reflux is introduced, which provides for liquid run-back. Thus, Section A could be called a fractionating column.

Feed enters in the mid portion of Section B, Tray F_B. Vapor is produced by the reboiler in the bottom section. Reflux runs back to the top tray of this section from Tray F_A. It, therefore, has all of the important characteristics of a fractionating column.

It would, therefore, appear that the fractionating tower, as used so commonly in the petroleum industry, can really be considered as a number of fractionating columns set one on top of the other. There are fractionating towers that have as many as six or more side streams as products.

Distillation equipment in the petroleum industry ranges from 18 in. in diameter to 30 ft in diameter, and possibly more. The pressure range goes from a top tower pressure of 1 mm to a top tower pressure as high as 500 psi.

Feeds to Be Separated

Probably one of the major differences between the normal chemical industry distillation operation and that of the petroleum industry lies in the nature of the materials handled. In general, the chemical industry is dealing with pure compounds whereas the oil industry is dealing with a vast number of materials boiling relatively close together. This is particularly true of those materials boiling above 200 to 250 F. Therefore, instead of talking about the boiling point of a material, the petroleum industry in general talks of a distillation range.

It should be noted, however, that in what the petroleum industry calls its "gas plant towers," it deals with pure compounds and can speak of their boiling point. The normal distillation range that is used has been obtained by an empirical method, spoken of as the ASTM distillation. Fig. 3 gives typical ASTM distillation curves. Curve A might be that for a light gasoline cut. That marked B might be considered as that of a naphtha, and that in C might be considered the "front end" of a light kerosine.

The oil industry, therefore, must use a different set of terms to indicate the efficiency of fractionation. When discussing a material and its distillation curve, the term "tail" is used. The right-hand end of the solid curves in Fig. 3 all deviate from a relatively straight line. The same is true of the

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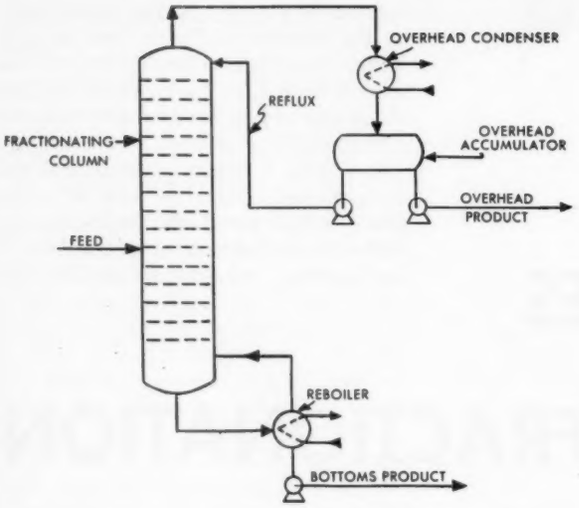


FIG. 1. Simple—and conventional—fractionating column separates feed into overhead and bottom products.

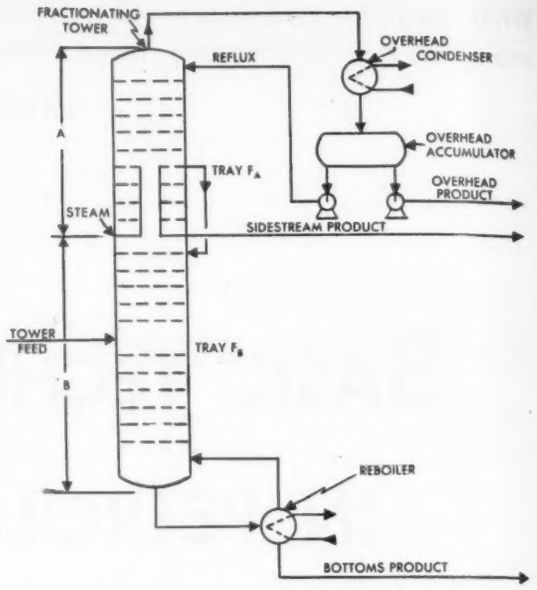


FIG. 2. The multi-sectional fractionating tower may separate six or more side streams as products.

left-hand end of curves B and C. The left-hand end is spoken of as "front-end tail," whereas the right-hand end is spoken of as "the heavy end tail."

If two materials are adjacent cuts, the terms "over-lap" and "gap" may be used. These terms normally refer to the number of degrees difference between the 95 per cent distilled point on the distillation curve of the lower boiling cut compared to the 5 per cent on the higher boiling cut. It is noticed that the comparison of the distillation curves in Fig. 3 shows that the solid curves are poor, as indicated by the tabulation on the right of the curves. There are dotted modifications of those distillation curves which change the picture considerably. In all cases the 50 per cent distilled point remains the same. Parenthetically, the 50 per cent distilled point is the point which is used in most of the distillation correlations for this type of material.One notices between the curves A^1 and B^1, this change results in no overlap, and between B^1 and C^1 it results in a 30 per cent gap. Therefore, the dotted curves show much better fractionation than is the case with the comparison of the solid curves.

Towers With No Reboilers

Another major difference between the distillation techniques of the petroleum and the chemical industries is the frequent use of distillation equipment in which there are no reboilers to produce vapor for the stripping section of the column. Fig. 4 illustrates this situation. The petroleum industry uses open steam to provide vapor for this stripping action.

One important reason for this technique is the fact that the temperatures encountered in the bottom of the normal petroleum fractionating tower are so high that it would be necessary to use a direct fired reboiler. Although this introduces but a minor complication, another factor also enters the picture. These temperatures are usually sufficiently high so that if additional hydrocarbon vapors were to be produced, the skin temperature in the fired heater would be at a level to cause thermal decomposition, with its attendant problem of the deposition of coke.

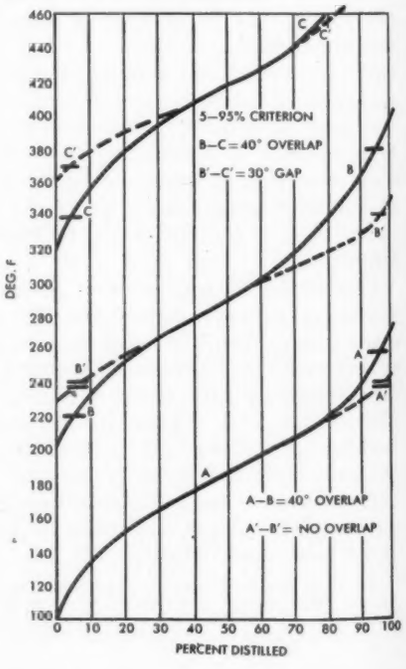
It is obvious that the equilibrium conditions within the tower, where the bulk of the vapor is composed of steam, differ considerably from the ideal. Therefore, one additional thing is often done. The feed, which is always composed of a mixture of vapor and liquid, usually contains a certain amount of "overflash." By this, it is meant that more vapor is present than is equivalent to the amount of distilled products that will be made in the tower. In this way the percentage of steam above the feed inlet is reduced below that which would otherwise be the case.

In the early part of this paper, the question of the fractionating tower with side stream products was discussed. It was pointed out that a fractionating tower really consists only of a number of fractionating columns, one on top of the other. There are two versions of a fractionating tower.

Towers With Internal Strippers

Fig. 5 shows a fractionating tower with internal strippers, or stripping sections. This was the first type of fractionating tower developed. It was found, however, that this type of construction was somewhat expensive and that the use of a vapor chimney or flue with annular trays was not as efficient as other types of construction. The normal type constructed today is shown in Fig. 6. This type uses the so-called external stripper. Usually the stripping tower is a multiple section vessel in the same shell. Internal heads are installed to divide it into the desired number of sections. The steam and the small amount of light ends vapor produced are returned to the main fractionating tower. This type of tower is used very widely throughout the processing facilities in the petroleum industry.

FIG. 3. Adjacent cuts may have overlapping ASTM distillation points.



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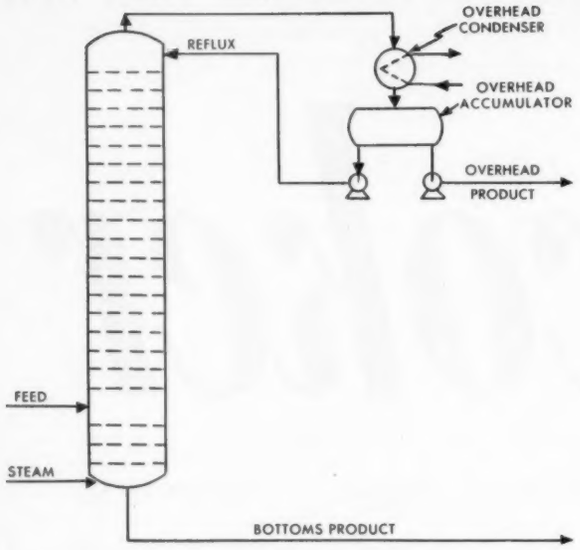

FIG. 4. Some distillation columns have no reboilers for the steam stripping section.

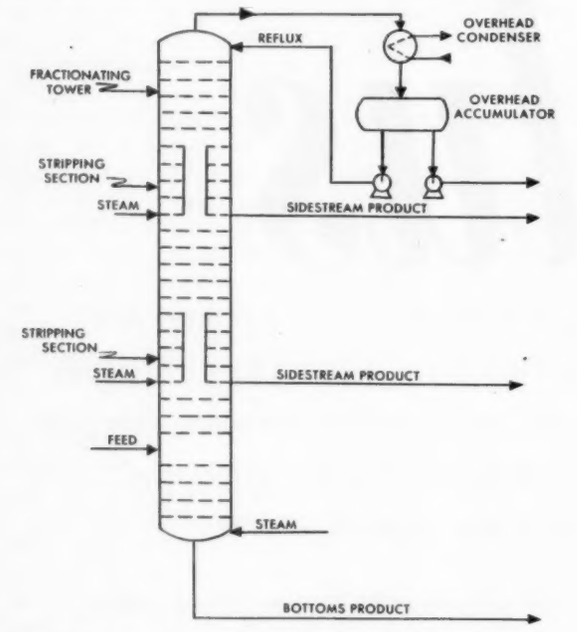

FIG. 5. Early towers with internal strippers proved expensive and inefficient.

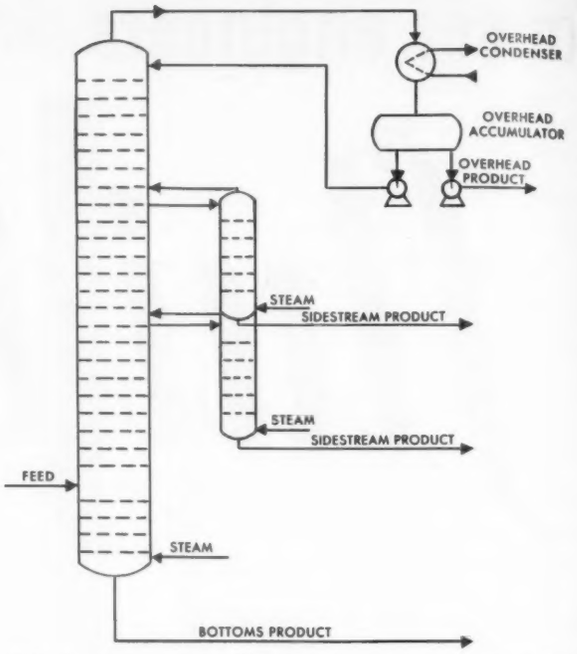

FIG. 6. Present developments have progressed to towers with external strippers now widely used in processing.

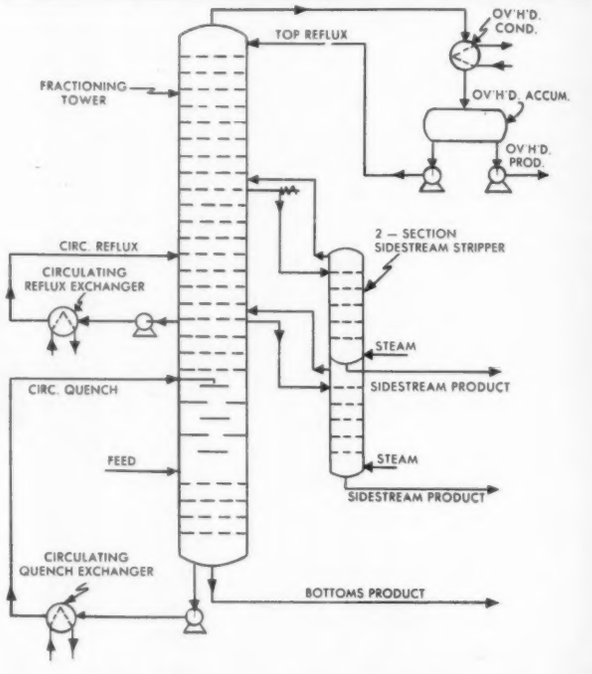

FIG. 7. Circulating quench and side reflux towers operate well above dew points of reaction zone vapors.

There is one special problem that occurs in the cracking units, whether these be thermal or catalytic. These processes all operate at a very high temperature, in the order of 900 to 1100 F. These temperatures are well above the dew point of the combined vapors leaving the reaction zone. Therefore, it is necessary to remove this super-heat.

The most satisfactory method is to "quench" the superheated vapor stream with cold oil. Fig. 7 illustrates one of the common methods of performing this operation. A stream of bottoms is pumped through heat exchange and returned to a heat transfer section. One of the common types of tray for this operation is the disk and doughnut construction. Heat removal is at a relatively high temperature level, thus making the heat available for heat exchange in the plant.

When the tower feed contains all the distilled product in vapor form and a substantial portion of the products are taken as liquid side streams, it is obvious that not only must sensible heat be removed to keep the tower in thermal balance, but also a substantial latent heat load must also be removed. This can be done by returning cold reflux to the top of the tower. The molecular weight, however, decreases substantially as one progresses up the tower. Thus the volume of vapor to be handled in the top of the tower can become very large.

In many cases, the petroleum industry uses "circulating side reflux" to assist in this connection. This is illustrated in the middle section of the tower shown in Fig. 7. The technique consists of withdrawing a liquid stream from the side of the tower, circulating

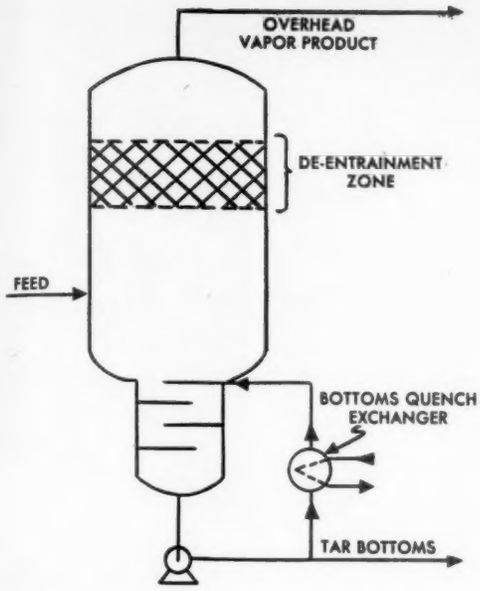

FIG. 8. High temperature flash distillation is used in feed preparation units for catalytic cracking.

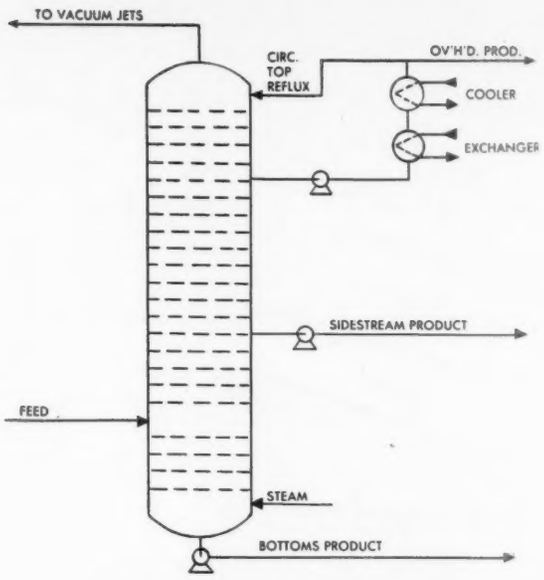

FIG. 9. Towers with a sufficiently cold circulating top reflux condense the entire overhead product.

it through heat exchange, and returning the liquid to a point higher in the tower. It is obvious that this technique disturbs the normal temperature profile to be expected in a fractionating column. Thus there is a loss of fractionation efficiency in those trays in the circulating reflux section.

It should be noted, however, that the temperature level of this circulating stream is such that the heat removed may be applied usefully in other parts of the plant. Care is also taken that the temperature range through which the cooling is allowed to take place is relatively small. This change is limited between 150 and 300 F.

The Author

Charles H. Brooks is a process engineer in the manufacturing department of Sun Oil Company. Brooks was formerly with the Socony - Vacuum Oil Company for 2 years, following graduation from Yale University in 1931. Upon completing graduate work at the University of Michigan, he joined Sun's research and development department in 1936. Brooks was transferred to the engineering division of the manufacturing department in 1940. A commander in the Navy during World War II, Brooks, upon his return to Sun in 1946, has done process design work on all phases of petroleum refining, including a large wax refining plant and a small complete refining-gasoline refinery.

Flash Distillation

The petroleum industry uses flash distillation to a great extent (Fig. 8). This is not a true fractionation, although it is normally considered as a part of that operation. This technique is widely used in feed preparation units for catalytic cracking. The feed, at a temperature as high as possible without danger from thermal cracking, is introduced into a large vessel. This vessel, in some cases, is under vacuum. In other cases it is under slight pressure above atmospheric, depending entirely on the overall processing scheme. The vessel contains a de-entrainment zone. This may be two to four bubble cap trays, over which a small amount of reflux is pumped, or, it may consist of one of the wire mesh de-entrainment pads which are becoming common today.

The bottom of the vessel is usually reduced in diameter because of the relatively small amount of liquid which is to be removed. Normally, a small portion of the bottoms is cooled and pumped back into the bottom of the vessel to cool the bottoms below the temperature where coking will be experienced. In the bottom of the tower, however, as the only velocity is liquid velocity, the retention time may be several minutes. This will be sufficient at temperatures of 800 to 850 deg to cause the laydown of coke.

The circulating reflux technique has been applied in vacuum towers. One of the problems that the oil industry faces is pollution. Vacuum towers are notoriously bad offenders in this respect. Oil is pulled over into the jets due to the size of the equipment normally used. The quantities of steam used in the jets are large, thus making it normally impractical to use surface condensers. By far the most common condenser in the oil industry for vacuum jets is the barometric condenser. Thus the oil is mixed with large volumes of water and becomes very well emulsified.

It has been found that if sufficient cold reflux is applied to the top of such a tower, as illustrated in Fig. 9, the entire overhead product may be condensed in the top section of the tower. Thus only the vapor leaving the top of the tower is process steam, with oil only as dictated by the partial pressure of oil vapor from the liquid on the top tray. The circulating reflux returned is usually as cold as normal cooling water will provide, thus the partial pressure of oil is very small. The amount of oil vapor carried to the vacuum jets is also small, and in this way the pollution problem is somewhat simplified.

Light Hydrocarbons

Up to this point the distillation techniques discussed have applied entirely to the multiple component systems that are experienced in a large portion of the petroleum processing facilities. There are relatively few unusual techniques where the materials to be handled can be fractionated into relatively pure compounds or very narrow boiling fractions. These operations are confined almost entirely to the light hydrocarbon processing facilities. The techniques in use in this part of the refinery are quite conventional.

The major problem in this part of a refinery arises from the fact that in certain of the operations, such as depropanization or debutanization of gasoline, the overhead product may contain three or more components whereas the

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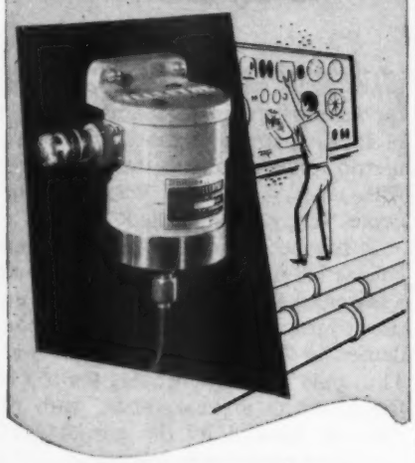

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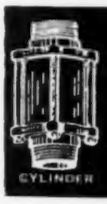
bottoms product may contain several dozen separate hydrocarbons. From time to time changes in the composition of the feed will affect not only the ratio of overhead to bottoms product, but also the character of each one. Thus the fractionation efficiency may vary within wide limits on the same column.

There are occasional cases, however, in this portion of the refinery, which have peculiar problems. One is encountered in connection with the production of gasoline by the polymerization of propylene. The feed to this operation is a propane-propylene mixture containing only traces of butane. The product from the reaction zone contains propane and a small amount of unreacted propylene and a "poly gasoline," consisting of C_6 and heavier hydrocarbons. Due to the high vapor pressure of propane, this is an undesirable constituent of gasoline. Butane is the normal material that is used to give proper volatility characteristic of gasoline.

It is seldom in this operation that sufficient butane is introduced with the feed to give sufficient vapor pressure to the poly gasoline, so that the proper design of fractionating column can be made. The reflux on the top of the tower will be propane. Therefore, the top tower pressure must be sufficiently high to condense this material at normal temperatures, say 100 F.

This pressure at the top of the tower will require, with the relatively low vapor pressure bottoms, a temperature of 400 to 425 F in the reboiler. This temperature is higher than in desirable when using 450 psig steam as the heat-medium in the reboiler. A hazard would be introduced if a fired reboiler were used because this equipment is normally located in a light hydrocarbon area. It should be noted, however, that butane must be added to the poly gasoline to raise its vapor pressure to the point where it would meet normal volatility requirements. Therefore, if this material be injected into the tower, the bottoms will have sufficient vapor pressure so that the reboiler temperature will drop to between 375 to 400 F. The temperature is satisfactory for use with 450 psi.

Azeotropic distillation, extractive distillation, etc., are used in the petrochemical phase of petroleum refining. These, however, are basically quite similar to the same types of operations in the chemical industry.



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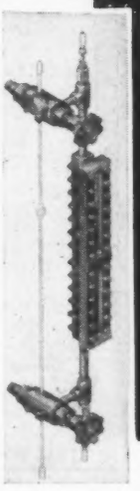

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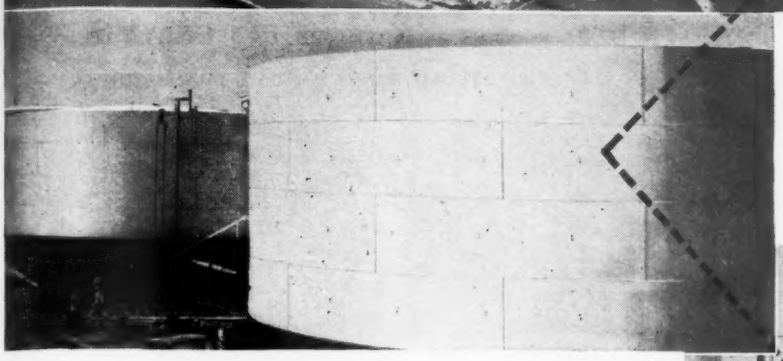

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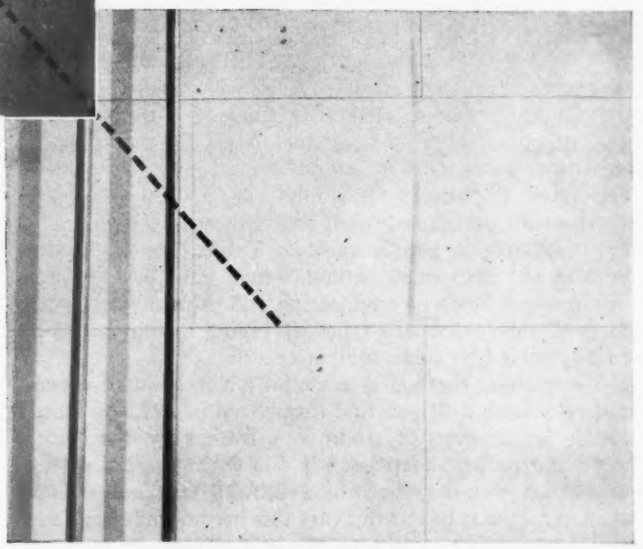

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Piping Stress Analysis

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Senior Mechanical Engineer, Sverdrup and Purcel, Inc.

SEVERAL methods for calculating expansion stresses in high temperature piping have been available to engineers. Although adopting one method or another is quite often a matter of personal preference and extent of mathematical background, each method definitely has its merits as well as its certain drawbacks and limitations. One would find a method adapts particularly well to one type of piping layout, but is unsuitable to handle another. This article attempts to show how the numerical method, which has been found so useful in many fields of engineering and physics, can be applied profitably to certain types of piping system problems not easily solved by other methods.

The numerical method is essentially a method of successive approximation. It was first formalized in 1932 by Hardy Cross[1] in his analysis of continuous frames by distributing fixed-end moments. Independently and with essential modifications it has been developed by Southwell[2] who called it the relaxation method. In recent years this method has been successfully applied to such a variety of problems as occurred in soil mechanics, heat transfer, fluid flow, electrical flow, etc.

The idea of the method, when applied to piping expansion problems, is readily grasped by those who are familiar with the Cross' method. For most mechanical engineers or piping designers with little background in dealing with statically indeterminate structures a brief explanation is necessary. The method is easy to memorize and once the principle is understood, the procedure involves nothing but the simplest arithmetic. The method excels all other known methods in solving 2-dimensional problems of more than two anchor points and of lines of different flexibility. (This type of layout is most common in oil refinery and in steam distribution systems.) Although the method can be applied to 3-dimensional problems, the procedure involved is even more tedious and time-consuming than the mathematical methods and is not recommended for use in this case.

Symbols and Definitions

Φ_{ba} = rotation of the member ab at b referred to its original position due to the joint displacements only.

Φ_{bc} = rotation of the member bc at b referred to its original position due to the joint displacements only.

M'_{ba} = "fixed-end" moment at b due to Φ_{ba}

M'_{bc} = "fixed-end" moment at b due to Φ_{bc}

$M_{ba} = -M_{bc}$ = the true moment at b

I = moment of inertia

E = modulus of elasticity

L = length of member

"Stiffness" of a member = the moment at one end of a member necessary to produce unit rotation of that end when the other end is fixed. For a pipe of constant section, the stiffness is proportional to $\frac{I}{L}$.

"Carry-over" factor = If one end of a member is rotated while the other end is held fixed, the ratio of the moment at the fixed end to the moment producing rotation at the rotating end is defined as the "carry-over" factor. For a pipe of constant section, the carry-over factor is equal to ½.

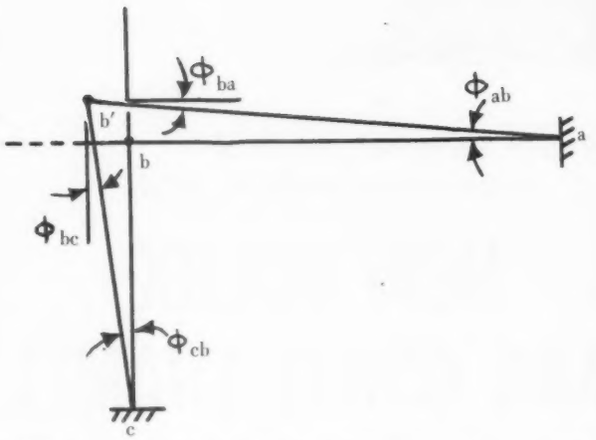


FIG. 1. Diagram for solving two-dimensional problems of more than two anchor points, and with lines of different flexibility.

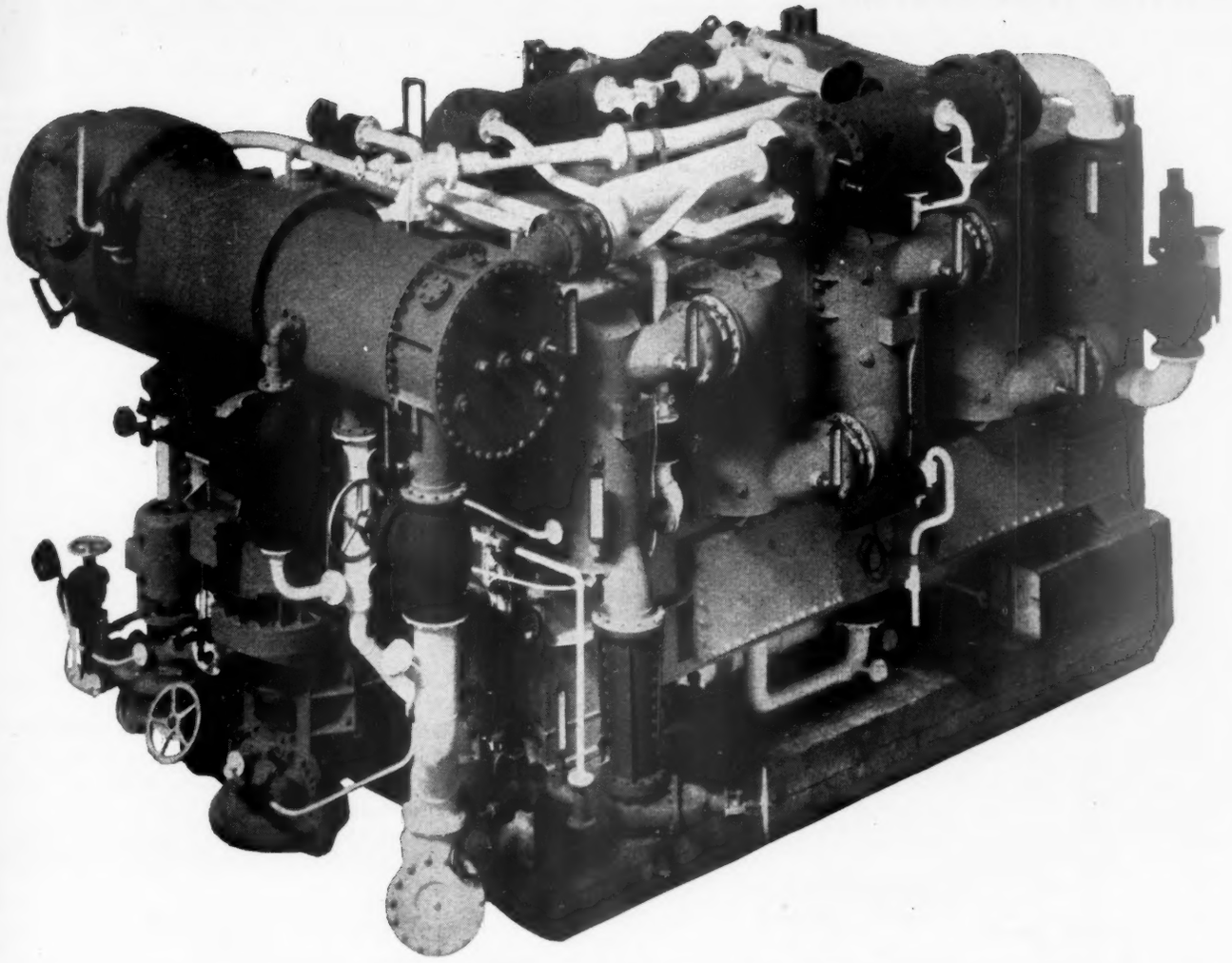
Signs of Rotation and Moment

Φ = positive when the member is rotated clockwise from its original position

M' = positive when it is acting clockwise $= -\frac{6EI\Phi}{L}$ under this sign convention.

When a piping system is subjected to temperature changes, each joint of its members moves and rotates until the final equilibrium state is reached. This simple fact suggests the procedure for numerical analysis as follows:

(1) Consider the joint moves first without rotation. This corresponds to the physical condition that each joint is held rigidly by a hypothetical anchor against rotation at its new position. (b′, Fig. 1.) We can easily compute the fixed-end moments due to these joint displacements. The algebraic sum of the fixed-end moment at each joint is not usually equal to



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zero ($M'_{ba} + M'_{bc} \neq 0$) and we call it the unbalanced fixed-end moment.

(2) Now we remove the hypothetical anchor and the joint is free to rotate. At the final equilibrium state, there must not be any unbalanced moment at the joint ($M_{ba} + M_{bc} = 0$) that is to say, the unbalanced moment before the joint is released ($M'_{ba} + M'_{bc}$) is distributed to the connecting members in some ratio. While all the connecting members at the joint must rotate through the same angle, the moment necessary to produce this same rotation is different for each member. By the definition of "stiffness" of a member, we therefore distribute the unbalanced fixed-end moment in proportion to this constant.

(3) The moment we just distribute to one end of each member at the joint induces a moment at the other end of the member. The latter is equal to the amount of the former multiplied by the "carry-over" factor. This follows directly from the definition of the factor.

(4) Distribute these moments just "carried-over."

(5) Repeat the process until the moments to be carried over are sufficiently small to affect the values of the final true moments required.

(6) The true moments at each end of the members is the sum of all moments at that end—the fixed-end moment, the distributed moments, and moments carried over.

The procedure established above is essentially that of Cross' with the exception of step (1) and a different sign convention throughout.

For the purpose of comparison we first take the simple L bend problem worked out by Spielvogel on p. 22 of his well-known book.[3]

Example I

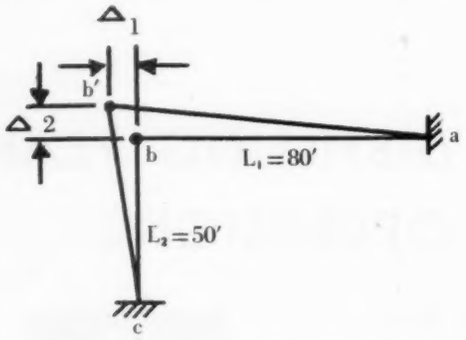

FIG. 2. Spielvogel problem, and

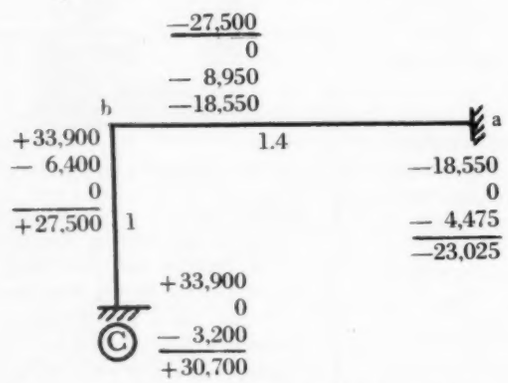

FIG. 3. Numerical values established and applied to the diagram for a solution.

Steam temperature = 700 F
Expansion = 5.75 in. per 100 ft
$E = 25 \times 10^6$ psi
For ab: $L_1 = 80'$ 12" Schedule 80 pipe
bc: $L_2 = 50'$ 10" Schedule 60 pipe

$$\Delta_1 = \frac{5.75}{100} \times 80 = 4.6''$$

$$\Delta_2 = \frac{5.75}{100} \times 50 = 2.88''$$

$$\frac{I_1}{L_1} = \frac{475}{80} = 5.95$$

$$\frac{I_2}{L_2} = \frac{212}{50} = 4.24$$

If we take the stiffness of bc as 1 unit, then the relative stiffness of ab $= 1 \times \frac{5.95}{4.24} = 1.4$. These values are marked with circles on Fig. 3.

The fixed-end moments are computed as follows:

$$M'_{ab} = M'_{ba} = -\frac{6EI_1}{L_1}\Phi_{ab} = -\frac{6EI_1}{L_1}\left(\frac{\Delta_2}{L_1}\right)$$

$$= -\frac{6 \times 25 \times 10^6 \times 475 \times 2.88}{80^2 \times 1728}$$

$$= -18{,}550 \text{ ft lb}$$

$$M'_{bc} = M'_{cb} = +\frac{6 \times 25 \times 10^6 \times 212 \times 4.6}{50^2 \times 1728}$$

$$= +33{,}900 \text{ ft lb}$$

Now we proceed to distribute the unbalanced fixed end moments,

(1) At a, the anchor is infinitely stiff and the unbalanced moments — 18,550 is distributed between the member ab and the anchor in the ratio $1:\infty$. The member gets none of it and a zero is recorded under — 18,550 (Fig. 3).

(2) At b, there is an unbalanced moment of + 33,900 — 18,550 = 15,350. This moment is distributed to ba and bc in ratio 1.4:1.

$$\text{To ba: } 15{,}350 \times \frac{1.4}{1 + 1.4} = 8950$$

$$\text{To bc: } 15{,}350 \times \frac{1}{1 + 1.4} = 6400$$

There is only one way to place the signs of the distributed moments so that the total algebraic sum of the moments at b is equal to zero. (i.e., 33,900 — 18,550 — 8950 — 6400 = 0).

(3) At c, same as at a,

All joints have now been balanced. Next we carry over one-half of the moments we just distributed from one end to the other end.

In ab: o from a to b
½ × (— 8950) = — 4475 from b to a
In bc: ½ × (— 6400) = — 3200 from b to c
o from c to b

Now there is no unbalanced moment at the joints and no further distribution of moments is necessary.

Add all the moments at each end of each member to obtain the true moment at the joint.

The forces at anchor can be easily obtained from laws of statics. This will be shown in detail in Example 2.

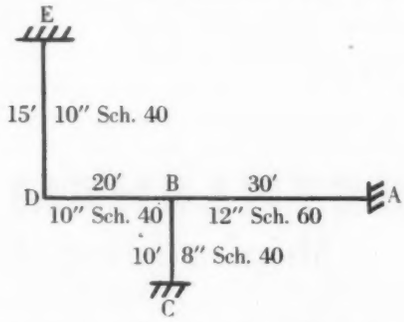

FIG. 4. Determination of forces at anchor.

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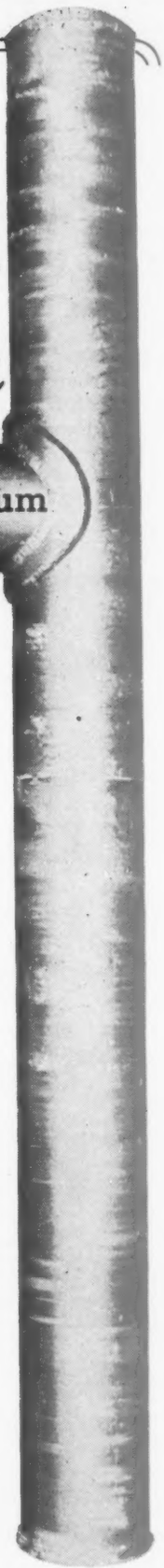

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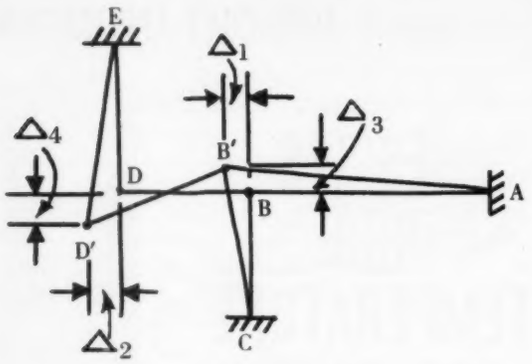

FIG. 5. Determination of forces at anchor.

Example 2

Carbon steel pipe
Operating temperature = 500 F
Expansion = 4 in. per 100 ft (from 32 F)
$E = 28.2 \times 10^6$ psi

	L (ft)	I (in.⁴)	I/L (in.⁴/ft)	Relative "stiffness"
AB	30	400.5	13.35	1.84
BC	10	72.5	7.25	1
BD	20	160.7	8.04	1.11
DE	15	160.7	10.70	1.48

$$\Delta_1 = \frac{4}{100} \times 30 = 1.2''$$

$$\Delta_2 = \frac{4}{100} \times 50 = 2.0''$$

$$\Delta_3 = \frac{4}{100} \times 10 = 0.4''$$

$$\Delta_4 = \frac{4}{100} \times 15 = 0.6''$$

$$M'_{AB} = M'_{BA} = -\frac{6 \times 28.2 \times 10^6 \times 13.35 \times 0.4}{30 \times 1728} = -17450 \text{ ft-lb}$$

$$M'_{BC} = M'_{CB} = +\frac{6 \times 28.2 \times 10^6 \times 7.25 \times 1.2}{10 \times 1728} = +85400 \text{ ft-lb}$$

$$M'_{BD} = M'_{DB} = +\frac{6 \times 28.2 \times 10^6 \times 8.04 \times (.4 + .6)}{20 \times 1728} = +39400 \text{ ft-lb}$$

$$M'_{DE} = M'_{ED} = -\frac{6 \times 28.2 \times 10^6 \times 10.7 \times 2}{15 \times 1728} = -140{,}000 \text{ ft-lb}$$

The unbalanced moment at B is 85400 + 39400 — 17450 = 107350. It is distributed as follows:

$$\text{To BA: } 107350 \times \frac{1.84}{1 + 1.11 + 1.84} = 50000$$

$$\text{To BC: } 107350 \times \frac{1}{1 + 1.11 + 1.84} = 27200$$

$$\text{To BD: } 107350 \times \frac{1.11}{1 + 1.11 + 1.84} = 30150$$

Note that these moments must have negative signs so that the total moments at B may be balanced.

To obtain the reactions at the anchors and for a better understanding of the sign convention, Fig. 7 is constructed by applying the laws of statics.

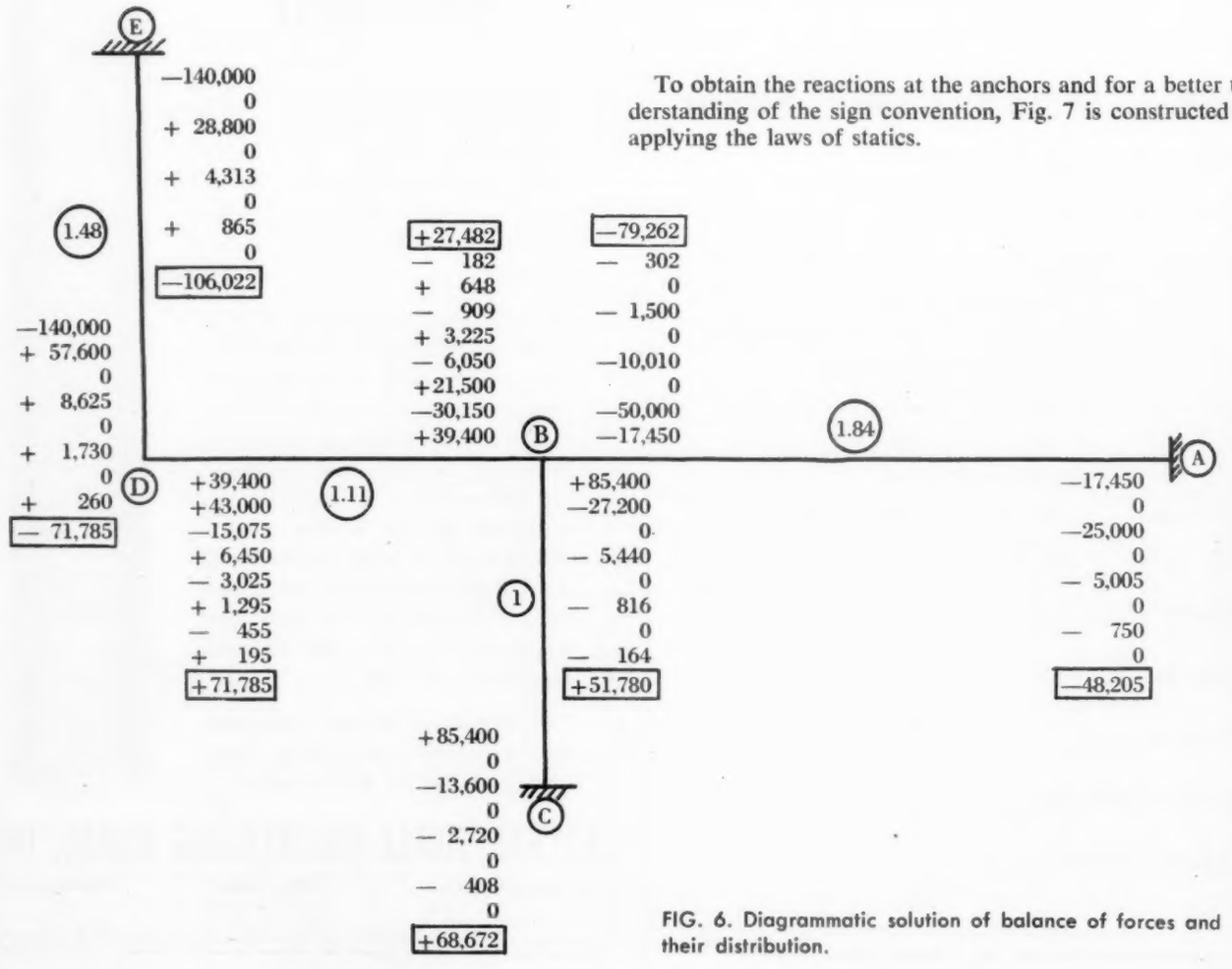

FIG. 6. Diagrammatic solution of balance of forces and their distribution.

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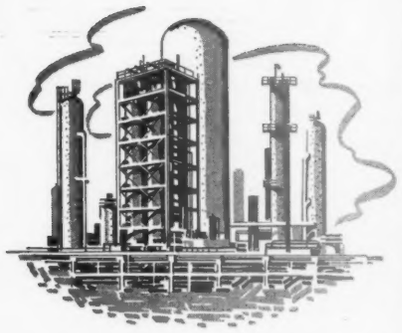

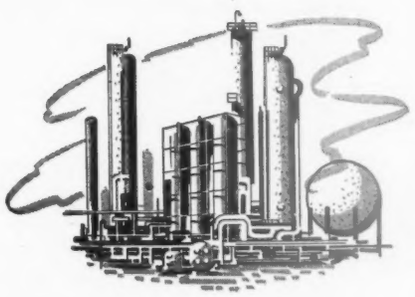

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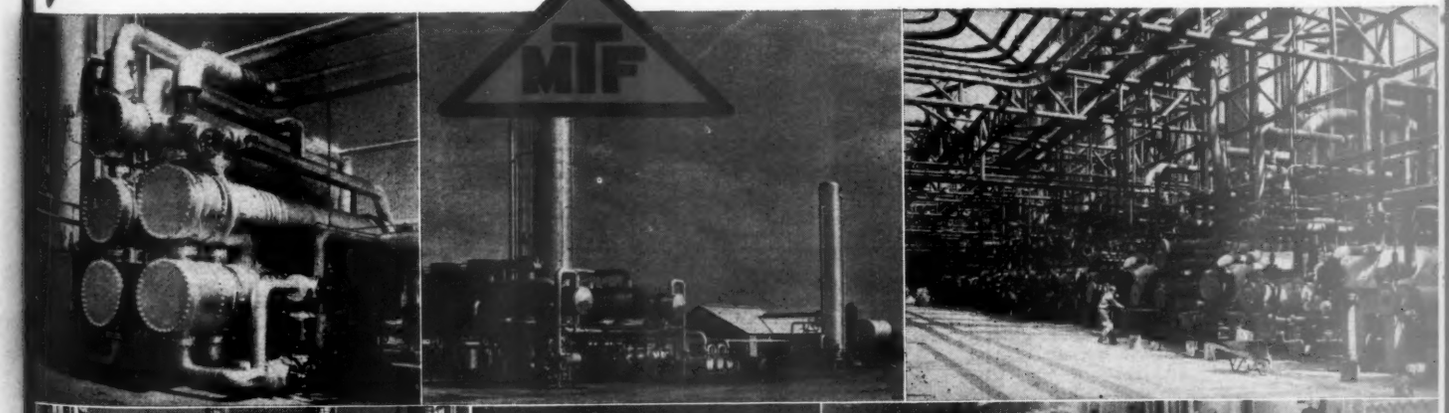

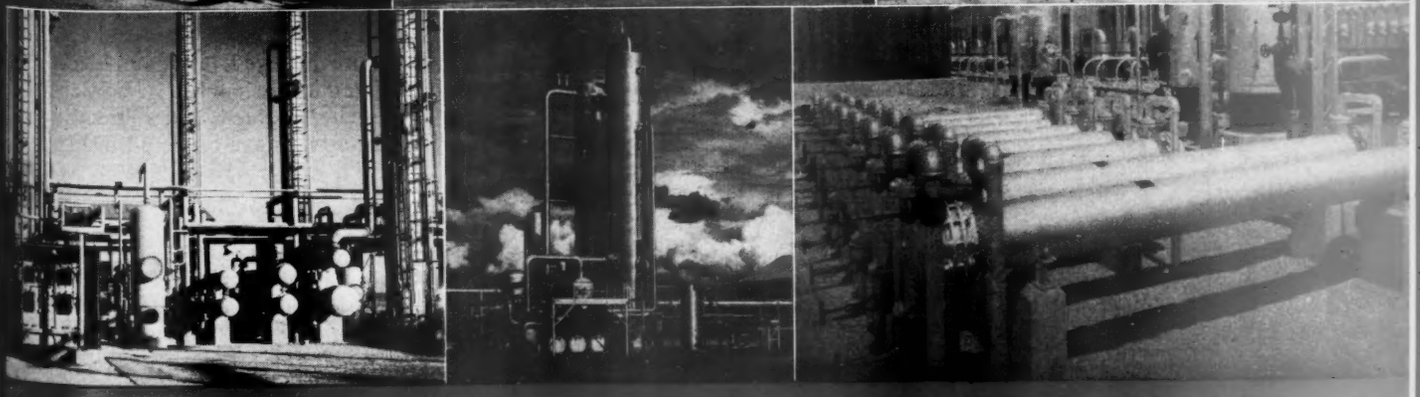

API-ASME and ASME Code Construction

$$V_1 = \frac{M_{AB} + M_{BA}}{L_1} = \frac{48205 + 79262}{30} = 4250 \text{ lb}$$

$$V_3 = \frac{M_{BD} + M_{DB}}{L_3} = \frac{27482 + 71785}{20} = 4960 \text{ lb}$$

$$H_2 = \frac{M_{BC} + M_{CB}}{L_2} = \frac{51780 + 68672}{10} = 12050 \text{ lb}$$

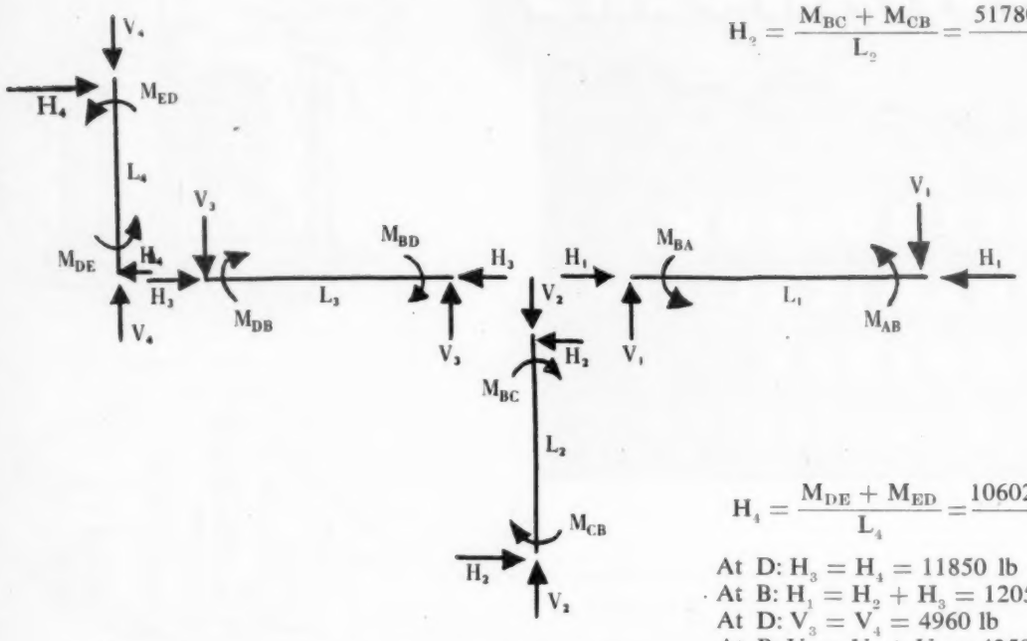

FIG. 7. Diagram of the laws of statics to determine reactions at the anchor sand for better understanding of the sign convention.

$$H_4 = \frac{M_{DE} + M_{ED}}{L_4} = \frac{106022 + 71785}{15} = 11850 \text{ lb}$$

At D: $H_3 = H_4 = 11850$ lb
At B: $H_1 = H_2 + H_3 = 12050 + 11850 = 23900$ lb
At D: $V_3 = V_4 = 4960$ lb
At B: $V_2 = V_1 + V_3 = 4250 + 4960 = 9210$ lb
The reactions at the anchors are shown on Fig. 8.

The reader will note that how simple it is to solve the L-bend problem by the numerical method as given in Example 1. All the steps required involve nothing but one moment distribution and one "carry-over" operation. The real merit of the numerical method is not to solve the simple 2-anchor problems such as the I, U or Z bends, however, as there are dozens of ready-made charts or graphs available in trade catalogs or magazines to aid in a quick solution of these most elementary types of piping layout. The real merit lies in its ability to handle the multi-anchor piping layout, such as the 3-anchor problem in Example 2, without getting involved in any complicated mathematical theory or the tedious and time-consuming solution of simultaneous equations. It will also

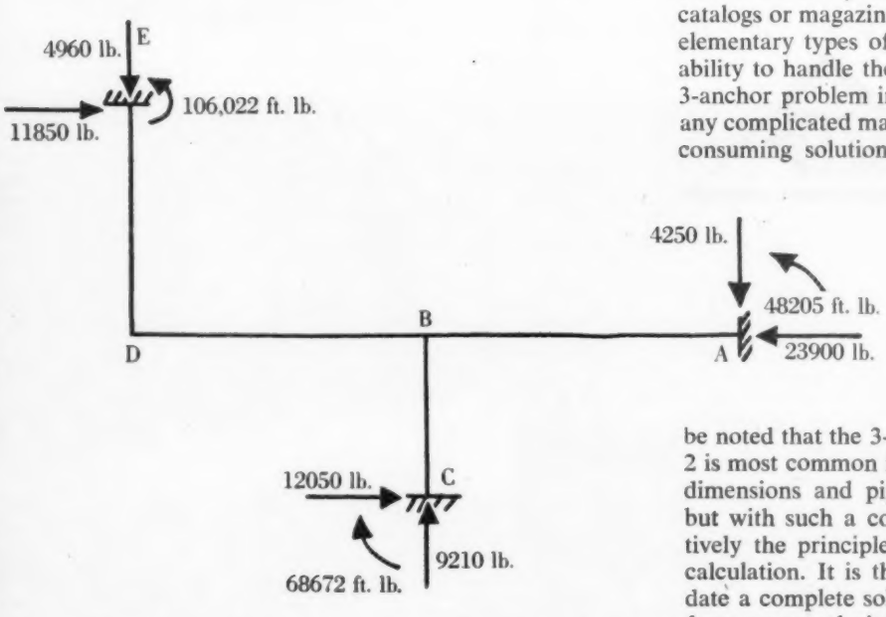

FIG. 8. Reactions at the anchors are found to be those shown here.

be noted that the 3-anchor configuration as given in Example 2 is most common in piping application. The run and branch dimensions and pipe sizes (Fig. 4) were chosen arbitrarily but with such a combination as to demonstrate most effectively the principle and procedure involved in a numerical calculation. It is the author's intention to publish at a later date a complete solution of 4-anchor problem taken directly from an actual piping layout for a two-stage crude oil distillation unit.

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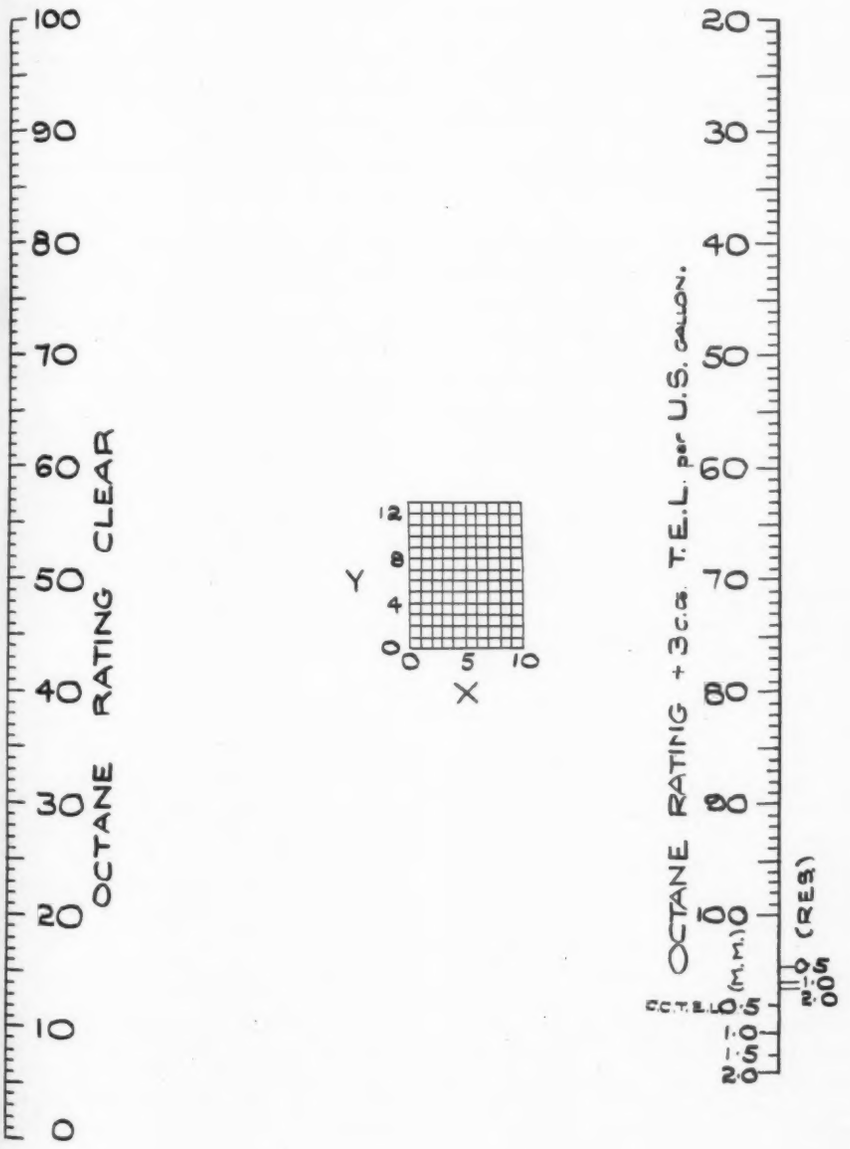
1. Cross, H., Trans. *Am. Soc. Civil Engr.* Vol. 96, p 1 (1932).
2. Christopherson, D. G., and Southwell, R. V., *Proc. Roy. Soc.* (A) 168, p. 317 (1938).
3. Spielvogel, S. W., *Piping Stress Calculations Simplified*, 1943, McGraw Hill.

* * *

Lead Susceptibility of Hydrocarbons and Gasolines

George E. Mapstone



Nomograph for lead susceptibility of hydrocarbons and gasolines.

The lead susceptibility of gasoline is a function of the amounts and types of hydrocarbons present and of the amount and type of impurities, particularly sulfur compounds present. Maples[1] has recently shown that there are definite relationships between the clear and leaded (3 cc) octane ratings of the various classes of hydrocarbons. Although these relationships cannot be taken as exact or as applying to any particular sample of gasoline or hydrocarbon they prove most valuable when trends or average results are required.

This nomograph has been designed to present these relationships in a convenient and compact form. To use the chart, first locate the coordinates of the sample in the hatched area and then connect by means of a straight edge to the given octane rating (clear or leaded). The line will cut the other octane rating scale at the required value.

For example it is desired to estimate the Research octane rating of an average thermally reformed gasoline when leaded to 3 cc per gallon if the clear octane rating is 75 (Research). From the key the co-ordinates for the Research susceptibility of a thermally reformed gasoline are X = 5.3; Y = 5.6. Connecting this point by means of a straight edge with 75 on the clear octane rating scale (left hand scale) gives 87 leaded octane rating on the right hand scale.

Key, nomograph for lead susceptibility of hydrocarbons and gasolines.

Hydrocarbon or gasoline	Method	X	Y
Paraffins	Motor	6.9	1.0
Paraffins	Research	4.9	1.6
Naphthenes	Motor	5.0	4.8
Naphthenes	Research	1.7	6.8
Mono olefines	Motor	4.5	4.5
Mono olefines	Research	7.8	2.3
Cyclo olefines	Motor	3.4	12.1
Cyclo olefines	Research	0.1	12.5
Straight run	Motor	2.8	4.3
Straight run	Research	4.3	6.0
Catalytically reformed	Motor	8.0	4.1
Catalytically reformed	Research	7.1	3.1
Thermally reformed or cracked	Motor	6.9	6.5
Thermally reformed or cracked	Resaerch	5.3	5.6
Catalytically cracked	Motor	8.3	6.7
Catalytically cracked	Research	6.3	5.0
Catalytically polymerized	Motor	7.1	8.1
Catalytically polymerized	Research	8.5	3.0

REFERENCE

1. Maples, R. E., *Petroleum Refiner*, 33; (9), 284-299, (1954).

★ ★ ★

Operating Experience With Amine Units for H_2S Removal

R. A. Feagan, H. L. Lawler, and M. H. Rahmes

SOUR natural gas must be treated for removal of hydrogen sulfide to produce marketable gas. The processes most widely used at the present time in the natural gas industry employ solutions of the ethanolamines. These are organic bases that have the property of reacting chemically with acidic gases at normal temperatures to effect their removal, but releasing them by decomposition of the amine salts at elevated temperatures. This property lends itself to a continuous process wherein sour gas is contacted at ordinary temperatures in one column by a circulating amine stream which is regenerated at the boiling point temperature and usually at lower pressure in a second column. Details of the process have been described adequately in the literature.[1, 2, 3, 4, 5] The process accomplishes essentially complete removal of carbon dioxide as well as hydrogen sulfide and will produce sweet gas which will meet readily the usual specifications of 0.25 gr H_2S per 100 CF.

The process may employ either monoethanolamine-water solutions for removal of hydrogen sulfide and carbon dioxide only or may employ a mixture of monoethanolamine, diethylene glycol, and water for simultaneous sweetening and dehydration. Diethanolamine solutions are sometimes employed, but find their principal application in refineries. The following discussion, however, deals solely with units employing MEA-H_2O solutions.

Much has been said and written about the design of H_2S removal units, and in recent years, a number of publications have discussed corrosion problems, particularly in amine-glycol systems.[6, 7, 8, 9] In spite of the relatively long time that amine units have seen commercial application — and in spite of a substantial research effort by the users, plant designers and manufacturers of amines and alloys — amine units continue to be a source of trouble and expense to many plant operators.

It is the purpose of this article to summarize briefly the tentative conclusions one company has reached based on four to five years' experience operating five H_2S removal units with aqueous monoethanolamine and on study of the experiences of other companies in this field. It must be emphasized that these conclusions regarding aqueous amine unit design and operation are tentative since all variables have not been sufficiently explored.

Presented before Natural Gasoline Association of America annual convention, Dallas, Texas.

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H. L. Lawler

M. H. Rahmes

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M. H. Rahmes is senior process engineer for Stanolind in Tulsa. Rahmes joined the company in 1948 as a junior process engineer. He is a graduate of the University of Cincinnati and has a MS degree from Tulsa University.

During 1953, the five H_2S removal units under discussion processed gas at a total average rate of 205,300,000 cu ft per day, and extracted acid gas (H_2S and CO_2) at a total average rate of 10,600,000 cu ft per day at a total cost (not including utilities, amortization, or overhead) of $808 per day, or about $76 per million cu ft of acid gas extracted. This expense can be roughly broken down as follows; maintenance, repairs, etc., 50 per cent; chemicals (primarily amine), 31 per cent, and operating labor, 19 per cent. Thus, the problems are, in the order of their importance, corrosion, amine losses, and frequency of operating upsets (such as foaming, failure to sweeten gas, etc.) calling for more operator attention and, consequently, higher operating labor costs.

Average gas processed by the five units during 1953 ranged from 8800 to 88,700,000 cu ft per day, acid gas removed ranged from an average of 330 to an average of 7,280,000 cu ft per day and total average operating cost ranged between $49 and $298 per million cu ft of acid gas removed. Design amine circulating rate for the five plants ranges between 97 and 1515 gal per minute, design gas handling capacity between 12 and 120,000,000 cu ft per day, design acid gas content between 0.9 and 24.5 per cent of the inlet gas. The units were designed and built by several different contractors, two of the plants feature "split flow" regeneration and one of these two is designed for "pressure" regeneration.

Costs mentioned above are substantially lower than those experienced during the early period of operation of these plants because of the numerous changes in design and operation made in some of the plants since start-up. Some of the costs reflect substantial expenditures for major repairs or revisions.

Corrosion

Corrosion has been experienced primarily in the reactivator reboilers, reactivators, solution pumps, heat exchangers and related piping. Reboiler life has ranged from two months to more than one year in the same plant, with the improvement credited to changes in design and operating practices. Carbon steel reboilers in other plants have lasted several years. One carbon steel reactivator tower has been completely replaced, two others repaired and modified after bubble cap trays were corroded away. A number of heat exchanger bundles have required repair or replacement while others have not failed to date.

All of the plants have experienced corrosion to some extent but, to date, the cost of corrosion in two of the

plants has been small. Amine losses have varied widely, foaming has been experienced at times, and there have been a few times that difficulty has been experienced in meeting sales gas specifications.

Recommendations

Obviously, time will not permit presentation of a detailed description of all operating experiences with these five units during the past four to five years. The brief descriptions above, however, were presented to indicate the type and scope of experiences upon which the following conclusions and recommendations have been based.

The following paragraphs will outline these conclusions and recommendations with a short discussion of each of them. As is so often the case, there must be a compromise, or economic balance, between initial investment and operating and maintenance costs. The authors do not have the data to draw this line precisely.

Some of the following suggestions may seem obvious but they are included to make the list as complete as possible. For convenience, recommendations are divided into two groups, (1) those that must be considered by the plant designer, and (2) suggestions for the plant operator. Following are the recommendations for the designer. He should:

1. Provide sufficient capacity to permit operating with low amine concentrations. Experience in the five plants discussed above has indicated a correlation between loading on the unit and corrosion troubles. The plants experiencing the least amount of corrosion have sufficient solution circulating capacity to permit satisfactory gas sweetening with amine concentration in the order of eight to ten per cent. Although it might not be economical to design a unit for such low solution concentration, it is recommended that a design concentration of 15 per cent MEA be used rather than the 20 to 30 per cent often proposed by investment-cost-conscious designers.

2. Avoid excessive reboiler heating medium temperatures. If steam is used for heating, excessive temperature is not usually a problem although there are indications that reboilers designed for relatively low heat flux, i.e., low pressure steam in the order of 50 to 75 psig, might have longer life than reboilers using high pressure steam. If other heat medium is used, such as hot oil, experience has shown that the problem can be critical. Both carbon steel and stainless steel reboiler bundles have failed in about 2 months when heated by oil entering at approximately 550 F. If hot oil is used, it is believed that the maximum temperature should be restricted to about 400 F[9] in an effort to limit amine film temperature. It should be recognized that even minor leaks may cause difficulties resulting from contamination of the solution by oil.

3. Avoid use of dissimilar metals. This applies particularly to regenerators and reboilers. Certain critical regenerator internals were constructed of stainless steel in one of the plants mentioned above. This caused serious bimetallic corrosion of the carbon steel shell at the point of contact. The same phenomenon has been experienced in hot amine lines (carbon steel) where some of the fittings were carbon-moly steel.

4. Give consideration to packed and lined regenerators rather than bubble tray towers. After encountering serious corrosion in several carbon steel towers equipped with carbon steel bubble trays, several of the regenerators in the five plants have been revamped, bubble cap trays removed, the regenerators lined with a two-inch sprayed cement mixture, and Raschig rings installed to replace the bubble cap trays. This system has proved satisfactory and has been adopted for new plant design.

5. Provide a suitable amine reclaimer. This is a small batch still operating on a slip stream amounting to one-half to one per cent of the design circulation rate. Its purpose is to remove from the circulating amine soluble but nonvolatile impurities such as decomposition and oxidation products of amine that are thought to contribute to corrosion. Usually a small amount of soda ash is added either directly to the reclaimer or to the circulating solution to accomplish more complete recovery of amine in the redistillation operation. Our experience indicates that amine redistillation is an important step in reducing corrosion. Decomposition of amine in the circulating system can be shown by comparing the results of several methods of analyses. Acid titration determines the total alkalinity, the Van Slyke indicates the primary amine group, and the Kjeldahl determines total nitrogen.

All these methods will give essentially identical MEA contents on a fresh solution. When decomposition begins or some reaction ties up or destroys the primary amine group, determinations by the three methods will begin to diverge. Another test used to indicate the corrosiveness of amine solution is the so-called "iron capacity test." In this test, the amine to be tested is contacted under certain specified and controlled conditions with powdered iron. The amount of iron dissolved is reported in parts per milion. To illustrate the effectiveness of amine reclaimers, results of tests on overhead and bottom streams from one reclaimer are shown in Table 1.

TABLE 1.

Determination	Feed	Bottoms	Overhead
Acid titration, as per cent MEA	17.5	45.1	19.5
Van Slyke, as per cent MEA	14.5	29.6	17.0
Kjeldahl, as per cent MEA	17.4	71.3	21.0
Iron capacity, ppm	47	1204	4

6. Provide an effective filter. In spite of all normal precautions, some corrosion takes place in amine systems. Corrosion products are in the circulating solution in the form of finely divided iron sulfide. This sludge has caused fouling of heat exchanger surfaces, plugging of some valves and lines, erosion of metal surfaces and even plugging of the regenerator and contactor columns. Several types of filters have been tested. It has been concluded that the precoated type filter using diatomaceous filter aid, although more expensive, is most satisfactory. It ordinarily operates on a slip stream from the hot rich amine to the regenerator.

7. Stress relieve major equipment. Stress relieving adds relatively little to the cost of equipment. Experience has shown that stress cracking is likely to occur in amine units, particularly where hot amine comes in contact with carbon steel that is not stress relieved. Some stress corrosion has been reported even in amine contactors. Consequently, the practice has been adopted of stress relieving all major items of equipment.

8. Design for lower reactivator operating pressure. Many amine units have been designed for "pressure regeneration" because higher operating pressure, in the range of 30 to 50 psig, increases the bottom temperature of the regenerator and is believed to result in more complete stripping of the solution, particularly with respect to CO_2. This improvement in stripping should permit designing for a larger acid gas pickup per gallon of solution circulated; therefore, reducing the design circulation rate. As experience is conflicting in this regard, there are indications that higher reactivator operating pressure increases reboiler, exchanger, and regenerator tower corrosion. Consequently, the practice has been adopted of designing for minimum reactivator pressure, the lower limit being set usually either by the pressure required to supply the acid gas to a sulfur plant or by the pressure required to force amine out of the regenerator through heat exchangers to a surge drum or pump suction.

9. Provide an efficient inlet scrubber to prevent liquid hydrocarbon from entering the amine contactor.

10. Design for low solution losses. Experience has shown that excessive solution losses are due to mechanical leakage or to amine entrainment. To combat this, solution pumps should be equipped with efficient mechanical seals, an efficient residue gas scrubber should be provided to recover amine entrained from the contactor, one or two water wash trays should be provided in the top section of the contactor and provision should be made to collect and reclaim any solution drained from equipment.

All designers know that even a well designed plant will not be satisfactory with careless or improper operation. In addition to following the more obvious measures to assure sweet gas, the operator should:

1. Use lowest amine solution strength that will give consistently sweet gas under the load conditions prevailing. This will reduce corrosiveness of the solution and will also reduce amine losses.
2. Establish and maintain effective reclaimer operation.
3. Establish and maintain effective filter operation.
4. Maintain equipment to prevent mechanical losses.
5. Operate the amine contactor with gas outlet temperature slightly higher than inlet temperature. This will prevent condensation of hydrocarbons in the contactor. Condensed hydrocarbons are believed to cause foaming and solution carryover. In some cases, foaming has been experienced even while this precaution was being observed. In these cases, it has been necessary to resort to a foam inhibitor such as octyl phenoxy ethanol.

The preceding discussion is not intended to present a complete list of problems which might be encountered during the design or operation of aqueous amine gas sweetening units, nor is it to be inferred that the above suggestions offer the optimum solution to any problem. Some of the suggestions apparently have solved satisfactorily some of the problems but in many cases the steps taken have only reduced the severity of the problem. Also, it is recognized that experience of other companies may have led them, with good reason, to different conclusions.

Conclusion

In formulating the above suggestions, the authors have had the benefit of the thoughts of a number of individuals in Stanolind Oil and Gas Company who are connected with the design and operation of amine units. The authors wish to express their appreciation to the management of Stanolind Oil and Gas for permission to present this paper.

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* * *

Largest Atom Smasher In Industry Purchased by Shell Development Company

A 3,000,000-volt particle accelerator—the most powerful radiation source available to industry—has been purchased for the Emeryville, California, research laboratory of Shell Development Company, Harold Gershinowitz, president, announced.

The unit, a Van de Graaff accelerator—sometimes called an "atom smasher" because it was originally used for nuclear research—will be the first of its size in the petroleum industry, and will be installed in June, 1956.

Shell scientists will use the accelerator in studying the effects of radiation on fuels, lubricants, plastics and other oil-derived products.

The machine produces a radiation field of extreme intensity, one several hundred times that of the most powerful radioactive cobalt source now used in industry.

Radiation produced by the accelerator is in the form of a high-intensity beam of electrons traveling at almost the speed of light. This beam is pinpointed to bombard a product, causing changes in its physical characteristics. It makes a plastic harder, increases its resistance to solvents and enables it to hold its shape at high temperatures.

With this powerful electron beam, Shell scientists hope to learn more about changes that take place in matter exposed to high energy radiation. Such information could lead to creation of new products.

The Van de Graaff accelerator, of which Shell will now own two, has two additional advantages over radioactive sources for industrial use: First, when turned off it presents no radiation hazard, whereas a cobalt source is always hazardous; and second, the accelerator is easily adapted to continuous production techniques such as conveyor belt treatment systems.

Shell's other accelerator, a two-million-volt machine, was installed in the company's Houston laboratory in September, 1954. Researchers use this machine in "aging" rocks atomically—by bombarding them with protons. The machine can reproduce in one week the amount of radio-activity to which a rock may have been exposed during ten million years in nature. Such studies can help scientists tell the age of rock formations and thus provide new clues in the search for oil.

The Houston machine is housed in a room with 2½-ft thick concrete walls, and an electrically operated nine-ton sliding door. A one-ton paraffin "shield" surrounds the target material. When the machine is in operation, no one is in the room. Closed circuit television shows what is going on inside.

REFINERY PLANTS SCHEDULED FOR COMPLETION

Isophthalic plant for California. A $7,000,000 plant for making isophthalic anhydride is being built for Standard Oil Company of California at Richmond, by H. K. Ferguson. Unit will make 50,000,000 lb of the product annually, to be consumed largely by the plastics and surface coatings industry. It is expected to be completed late this year.

★ ★ ★

Cat reformer for Sarnia. Imperial Oil will build a "platinum catalyst" reformer unit at its Sarnia, Ontario, refinery. Fluor Corporation of Canada, Ltd., will do the mechanical designing and construction, based on process design plans by Imperial's engineering staff. Unit will process 13,500 bbl daily of naphtha and is expected to be completed late in September, 1955.

★ ★ ★

Ammonia plant for Puerto Rico. Anhydrous ammonia, ammonium sulfate, and sulfuric acid will be manufactured by a new plant being built at Guanica, Puerto Rico for Gonzales Chemical Industries, Inc., of San Juan. Lummus Company of New York City is designing and building the plant, which will make 42,000 tons of ammonia annually. This is the first such unit for Puerto Rico.

★ ★ ★

Lube plant for Iraq. A complete lubricating oil plant for Iraq has been contracted for by that government, with Foster Wheeler Corporation, England, to produce 25,000 tons of lubricants annually. Units will include vacuum distillation, propane deasphalting, furfural solvent extraction, propane dewaxing, clay percolation, and acid treating, along with auxiliary equipment and facilities.

★ ★ ★

Canadian oil builds office. A new administration and protection building is to be built for Canadian Oil Companies, Ltd., at its Sarnia refinery. Designed by G. S. Adamson and Associates, Toronto, Ontario, it will be built by Con-Eng Contractors, Ltd., London, Ontario.

★ ★ ★

High octane unit slated by Aurora. Aurora Gasoline Company is installing the world's first UOP Rexforming unit, said to be capable of producing over 100-octane premium gasoline.

The company is expanding refining facilities at the Detroit refinery by converting an existing UOP Platforming unit to a Rexforming unit by addition of new octane extraction process which separates highest octane components from Platformate, returning the remainder to reactors of the Platforming unit for further upgrading.

The Rexformer will have a design capacity of 5500-bbl-per-day of fresh feed. It is the first to be licensed by Universal Oil Products Company since UOP recently announced the availability of this super-fuel producing process to the petroleum industry.

★ ★ ★

New refinery electrical system. A complete new electrical system has been built for Stanovan Refinery in British Columbia, Canada. It serves a crude unit, cat cracker, polymer and steam plants, and auxiliaries. Purchased power from Vancouver comes into a substation via two 12-kv circuits from a main substation a few miles away and is distributed all over the plant, which is about a mile from the distribution center. An emergency generator in the refinery is designed to serve only the cat cracker and the polymer plant.

★ ★ ★

Another delayed coker. American Oil Company, Standard of Indiana subsidiary, has decided on and is building a delayed coker unit at its Yorktown, Virginia, refinery to convert heavy residuals from crude and from cracking distillations to coke and intermediate (gas oil) type distillates suitable for thermal or catalytic cracking to motor fuel. This process, developed a quarter-century ago by R. E. (Bob) Wilson, now Standard's board chairman, is one of those now solving the problem of disposal and utilization of heavy residues, no longer required in great quantities for railroad locomotives and analogous uses.

★ ★ ★

More helium capacity to build. U. S. Bureau of Mines will build a $6,000,000 helium plant of 100,000,000 cu ft per year at Exell, Texas, where an older plant of 85,000,000 cu ft per year already is operating. Bids on the construction will be asked for shortly, it is stated. This unit will boost helium capacity to about 300,000,000 cu ft yearly and may enable the bureau to meet demands for 1959 or 1960. As of now, less essential uses of helium have been cut off, although the last fiscal year produced 212,000,000 cu ft.

Canadian platformer-unifiner on stream. The first combination of these two processes in a unit outside the United States went on stream recently at the McColl-Frontenac Oil Company refinery near Montreal, Quebec, Canada. Unit has 11,970 bbl per day capacity, the Unifiner being the feed preparation unit for the reformer, which will operate on fractions from Arabian and/or Venezuelan crudes Universal Oil Products Company, licensed and designed the units, and Procon, UOP construction-engineering subsidiary, built them.

★ ★ ★

Cat reformer for Continental. Invitations for bids on building a catalytic reformer at the Artesia, New Mexico, refinery of Continental Oil Company have been sent out. Nature of the process to be installed has not been disclosed. The unit is expected to be completed by about the first of January.

★ ★ ★

Rexformer for Cosden. Already operating a Platformer-Udex combination for making aviation blending fuel and aromatics, Cosden Petroleum Corporation has contracted with Universal Oil Products Company for a 3868-bbl-per-day Rexforming unit to meet demands for higher and higher octane rating motor and aviation fuels. The Platformer-Udex units will continue to make high purity aromatics. A five-tower prefractionation assembly will produce charge stock for these units. The Rexformer will be built by Procon, Inc. Cosden refinery staff is building a 1600-bbl Uniforming unit to be used to desulfurize a portion of the catalytic reforming units. The Rexformer will be finished by the spring of 1956, the Unifiner will be on stream "shortly."

Aerial view of the port at Adén, Arabia, of the British Petroleum Company's refinery (formerly Anglo-Iranian Oil Company), a plant of 100,000 bbl crude capacity per day, which processed more than 25,000,000 bbl in the last 12 months since going on stream. All crude was received at this port, which can accommodate four large tankers simultaneously. In the past year, 200 tankers discharged crude here, 130 loaded finished products.

Piping Stress Analysis

as applied to numerical methods

Special advantages are found in this method for certain problems

L. H. Chen
Senior Mechanical Engineer, Sverdrup and Purcel, Inc.

SEVERAL methods for calculating expansion stresses in high temperature piping have been available to engineers. Although adopting one method or another is quite often a matter of personal preference and extent of mathematical background, each method definitely has its merits as well as its certain drawbacks and limitations. One would find a method adapts particularly well to one type of piping layout, but is unsuitable to handle another. This article attempts to show how the numerical method, which has been found so useful in many fields of engineering and physics, can be applied profitably to certain types of piping system problems not easily solved by other methods.

The numerical method is essentially a method of successive approximation. It was first formalized in 1932 by Hardy Cross[1] in his analysis of continuous frames by distributing fixed-end moments. Independently and with essential modifications it has been developed by Southwell[2] who called it the relaxation method. In recent years this method has been successfully applied to such a variety of problems as occurred in soil mechanics, heat transfer, fluid flow, electrical flow, etc.

The idea of the method, when applied to piping expansion problems, is readily grasped by those who are familiar with the Cross' method. For most mechanical engineers or piping designers with little background in dealing with statically indeterminate structures a brief explanation is necessary. The method is easy to memorize and once the principle is understood, the procedure involves nothing but the simplest arithmetic. The method excels all other known methods in solving 2-dimensional problems of more than two anchor points and of lines of different flexibility. (This type of layout is most common in oil refinery and in steam distribution systems.) Although the method can be applied to 3-dimensional problems, the procedure involved is even more tedious and time-consuming than the mathematical methods and is not recommended for use in this case.

Symbols and Definitions

Φ_{ba} = rotation of the member ab at b referred to its original position due to the joint displacements only.

Φ_{bc} = rotation of the member bc at b referred to its original position due to the joint displacements only.

M'_{ba} = "fixed-end" moment at b due to Φ_{ba}

M'_{bc} = "fixed-end" moment at b due to Φ_{bc}

M_{ba} = $-M_{bc}$ = the true moment at b

I = moment of inertia

E = modulus of elasticity

L = length of member

"Stiffness" of a member = the moment at one end of a member necessary to produce unit rotation of that end when the other end is fixed. For a pipe of constant section, the stiffness is proportional to $\frac{I}{L}$.

"Carry-over" factor = If one end of a member is rotated while the other end is held fixed, the ratio of the moment at the fixed end to the moment producing rotation at the rotating end is defined as the "carry-over" factor. For a pipe of constant section, the carry-over factor is equal to ½.

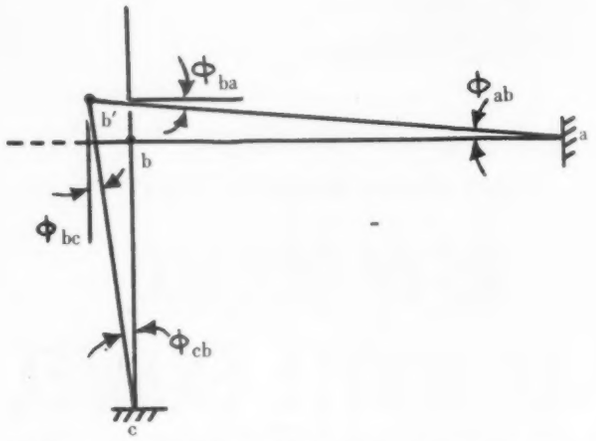


FIG. 1. Diagram for solving two-dimensional problems of more than two anchor points, and with lines of different flexibility.

Signs of Rotation and Moment

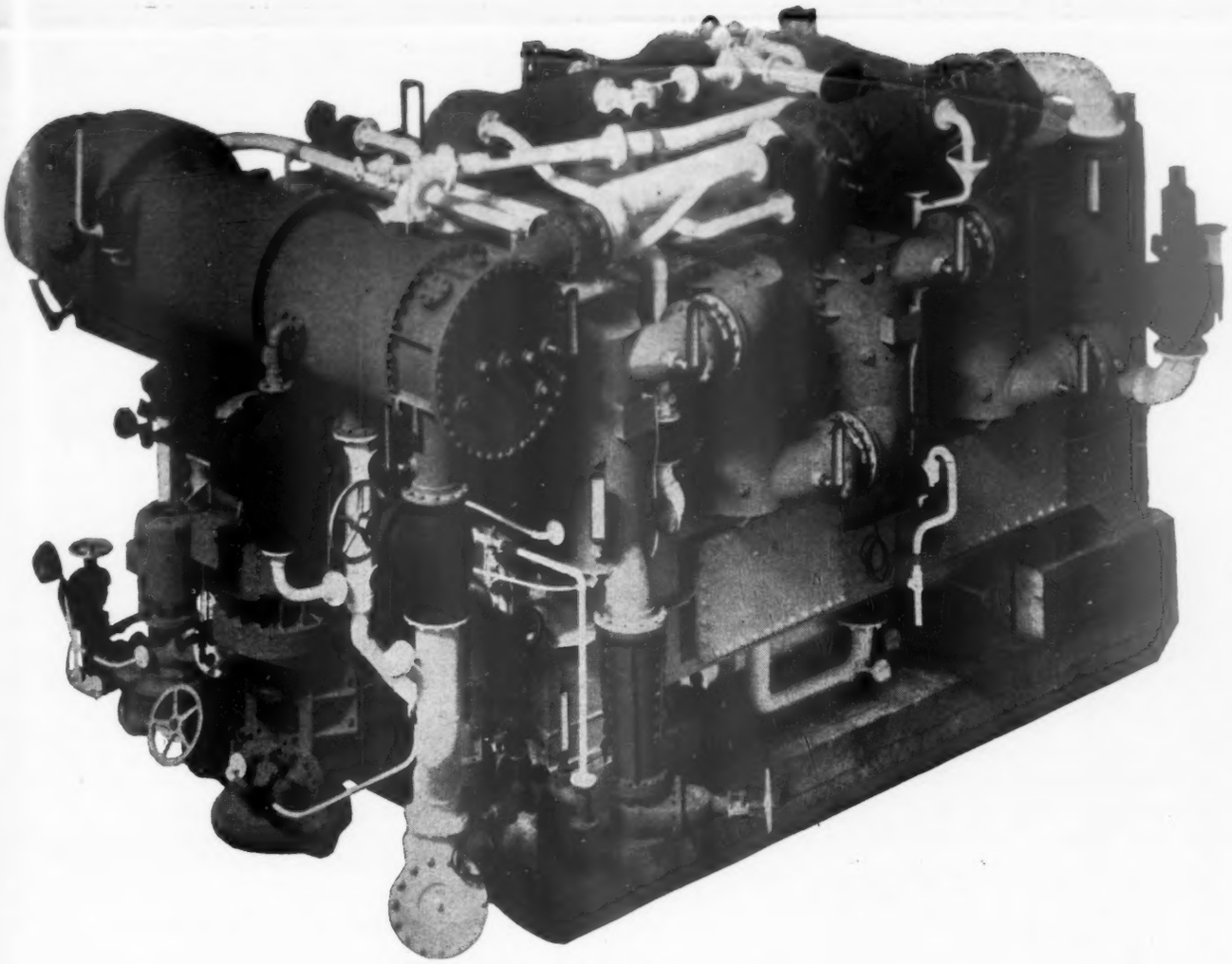
Φ = positive when the member is rotated clockwise from its original position

M' = positive when it is acting clockwise = $-\frac{6EI\Phi}{L}$

under this sign convention.

When a piping system is subjected to temperature changes, each joint of its members moves and rotates until the final equilibrium state is reached. This simple fact suggests the procedure for numerical analysis as follows:

(1) Consider the joint moves first without rotation. This corresponds to the physical condition that each joint is held rigidly by a hypothetical anchor against rotation at its new position. (b', Fig. 1.) We can easily compute the fixed-end moments due to these joint displacements. The algebraic sum of the fixed-end moment at each joint is not usually equal to



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zero ($M'_{ba} + M'_{bc} \neq 0$) and we call it the unbalanced fixed-end moment.

(2) Now we remove the hypothetical anchor and the joint is free to rotate. At the final equilibrium state, there must not be any unbalanced moment at the joint ($M_{ba} + M_{bc} = 0$) that is to say, the unbalanced moment before the joint is released ($M'_{ba} + M'_{bc}$) is distributed to the connecting members in some ratio. While all the connecting members at the joint must rotate through the same angle, the moment necessary to produce this same rotation is different for each member. By the definition of "stiffness" of a member, we therefore distribute the unbalanced fixed-end moment in proportion to this constant.

(3) The moment we just distribute to one end of each member at the joint induces a moment at the other end of the member. The latter is equal to the amount of the former multiplied by the "carry-over" factor. This follows directly from the definition of the factor.

(4) Distribute these moments just "carried-over."

(5) Repeat the process until the moments to be carried over are sufficiently small to affect the values of the final true moments required.

(6) The true moments at each end of the members is the sum of all moments at that end—the fixed-end moment, the distributed moments, and moments carried over.

The procedure established above is essentially that of Cross' with the exception of step (1) and a different sign convention throughout.

For the purpose of comparison we first take the simple L bend problem worked out by Spielvogel on p. 22 of his well-known book.[3]

Example 1

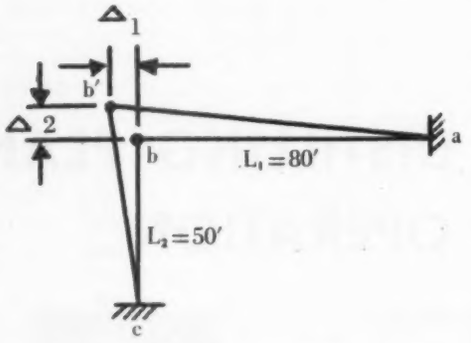

FIG. 2. Spielvogel problem, and

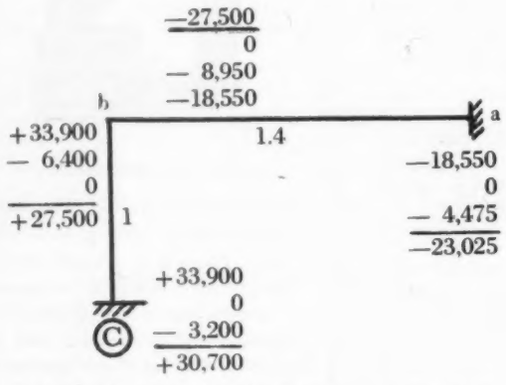

FIG. 3. Numerical values established and applied to the diagram for a solution.

Steam temperature = 700 F
Expansion = 5.75 in. per 100 ft
$E = 25 \times 10^6$ psi
For ab: $L_1 = 80'$ 12" Schedule 80 pipe
bc: $L_2 = 50'$ 10" Schedule 60 pipe

$$\Delta_1 = \frac{5.75}{100} \times 80 = 4.6''$$

$$\Delta_2 = \frac{5.75}{100} \times 50 = 2.88''$$

$$\frac{I_1}{L_1} = \frac{475}{80} = 5.95$$

$$\frac{I_2}{L_2} = \frac{212}{50} = 4.24$$

If we take the stiffness of bc as 1 unit, then the relative stiffness of ab $= 1 \times \frac{5.95}{4.24} = 1.4$. These values are marked with circles on Fig. 3.

The fixed-end moments are computed as follows:

$$M'_{ab} = M'_{ba} = -\frac{6EI_1}{L_1}\Phi_{ab} = -\frac{6EI_1}{L_1}\left(\frac{\Delta_2}{L_1}\right)$$

$$= -\frac{6 \times 25 \times 10^6 \times 475 \times 2.88}{80^2 \times 1728}$$

$$= -18{,}550 \text{ ft lb}$$

$$M'_{bc} = M'_{cb} = +\frac{6 \times 25 \times 10^6 \times 212 \times 4.6}{50^2 \times 1728}$$

$$= +33{,}900 \text{ ft lb}$$

Now we proceed to distribute the unbalanced fixed end moments,

(1) At a, the anchor is infinitely stiff and the unbalanced moments —18,550 is distributed between the member ab and the anchor in the ratio $1:\infty$. The member gets none of it and a zero is recorded under —18,550 (Fig. 3).

(2) At b, there is an unbalanced moment of + 33,900 — 18,550 = 15,350. This moment is distributed to ba and bc in ratio 1.4:1.

$$\text{To ba: } 15{,}350 \times \frac{1.4}{1 + 1.4} = 8950$$

$$\text{To bc: } 15{,}350 \times \frac{1}{1 + 1.4} = 6400$$

There is only one way to place the signs of the distributed moments so that the total algebraic sum of the moments at b is equal to zero. (i.e., 33,900 — 18,550 — 8950 — 6400 = 0).

(3) At c, same as at a,

All joints have now been balanced. Next we carry over one-half of the moments we just distributed from one end to the other end.

In ab: o from a to b
½ × (— 8950) = — 4475 from b to a
In bc: ½ × (— 6400) = — 3200 from b to c
o from c to b

Now there is no unbalanced moment at the joints and no further distribution of moments is necessary.

Add all the moments at each end of each member to obtain the true moment at the joint.

The forces at anchor can be easily obtained from laws of statics. This will be shown in detail in Example 2.

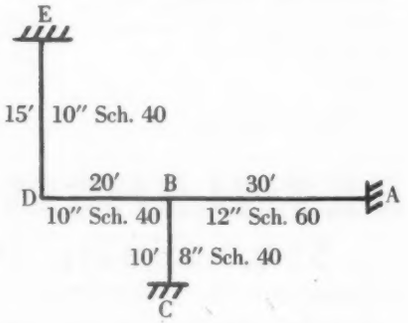

FIG. 4. Determination of forces at anchor.

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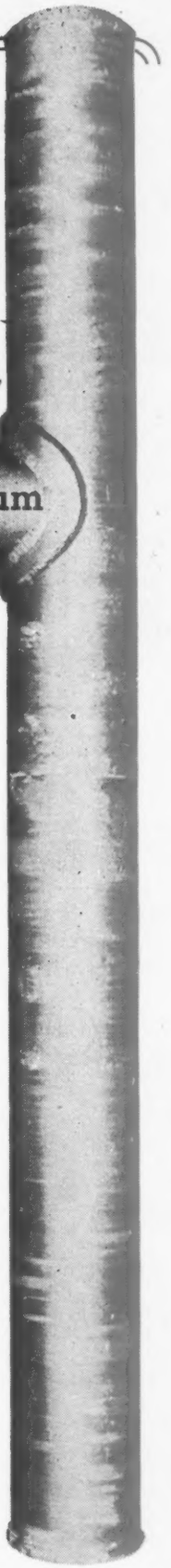

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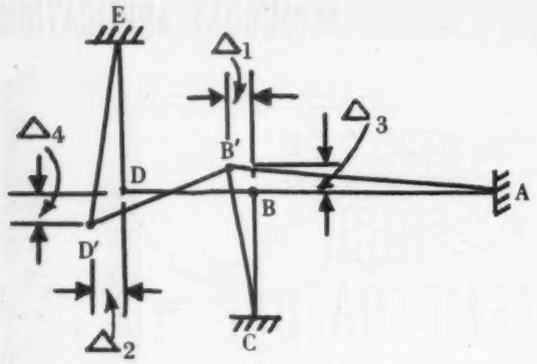

FIG. 5. Determination of forces at anchor.

Example 2

Carbon steel pipe
Operating temperature = 500 F
Expansion = 4 in. per 100 ft (from 32 F)
$E = 28.2 \times 10^6$ psi

	L (ft)	I (in.⁴)	I/L (in.⁴/ft)	Relative "stiffness"
AB	30	400.5	13.35	1.84
BC	10	72.5	7.25	1
BD	20	160.7	8.04	1.11
DE	15	160.7	10.70	1.48

$$\Delta_1 = \frac{4}{100} \times 30 = 1.2''$$

$$\Delta_2 = \frac{4}{100} \times 50 = 2.0''$$

$$\Delta_3 = \frac{4}{100} \times 10 = 0.4''$$

$$\Delta_4 = \frac{4}{100} \times 15 = 0.6''$$

$$M'_{AB} = M'_{BA} = -\frac{6 \times 28.2 \times 10^6 \times 13.35 \times 0.4}{30 \times 1728} = -17450 \text{ ft-lb}$$

$$M'_{BC} = M'_{CB} = +\frac{6 \times 28.2 \times 10^6 \times 7.25 \times 1.2}{10 \times 1728} = +85400 \text{ ft-lb}$$

$$M'_{BD} = M'_{DB} = +\frac{6 \times 28.2 \times 10^6 \times 8.04 \times (.4 + .6)}{20 \times 1728} = +39400 \text{ ft-lb}$$

$$M'_{DE} = M'_{ED} = -\frac{6 \times 28.2 \times 10^6 \times 10.7 \times 2}{15 \times 1728} = -140{,}000 \text{ ft-lb}$$

The unbalanced moment at B is 85400 + 39400 — 17450 = 107350. It is distributed as follows:

$$\text{To BA: } 107350 \times \frac{1.84}{1 + 1.11 + 1.84} = 50000$$

$$\text{To BC: } 107350 \times \frac{1}{1 + 1.11 + 1.84} = 27200$$

$$\text{To BD: } 107350 \times \frac{1.11}{1 + 1.11 + 1.84} = 30150$$

Note that these moments must have negative signs so that the total moments at B may be balanced.

To obtain the reactions at the anchors and for a better understanding of the sign convention, Fig. 7 is constructed by applying the laws of statics.

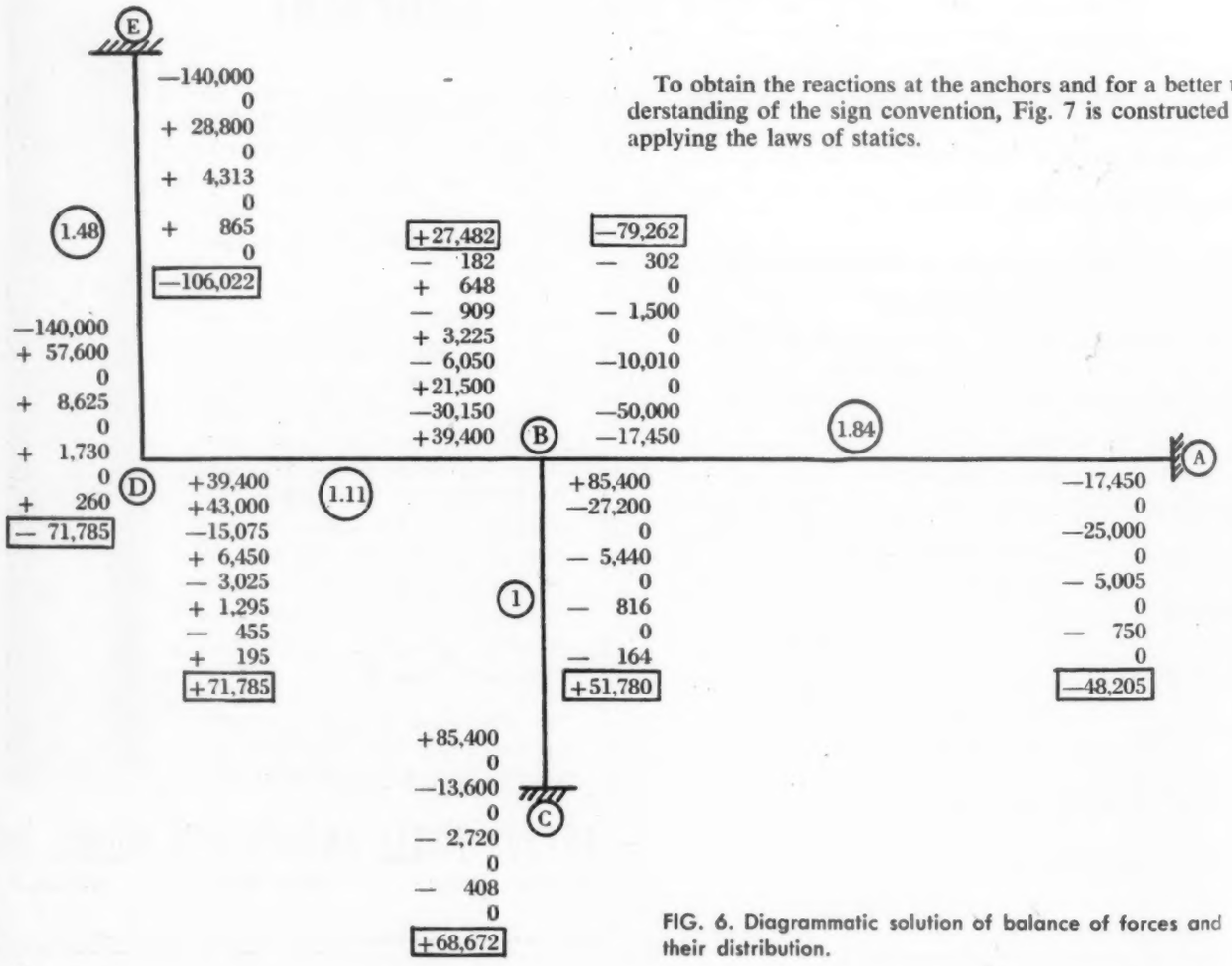

FIG. 6. Diagrammatic solution of balance of forces and their distribution.

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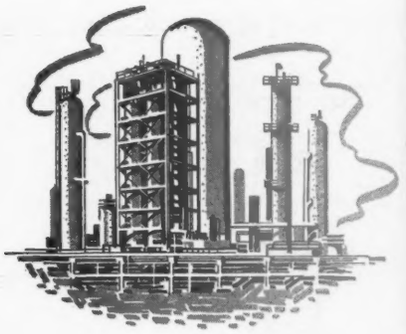

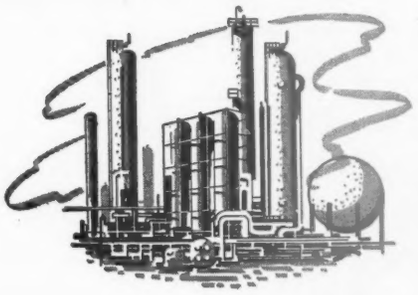

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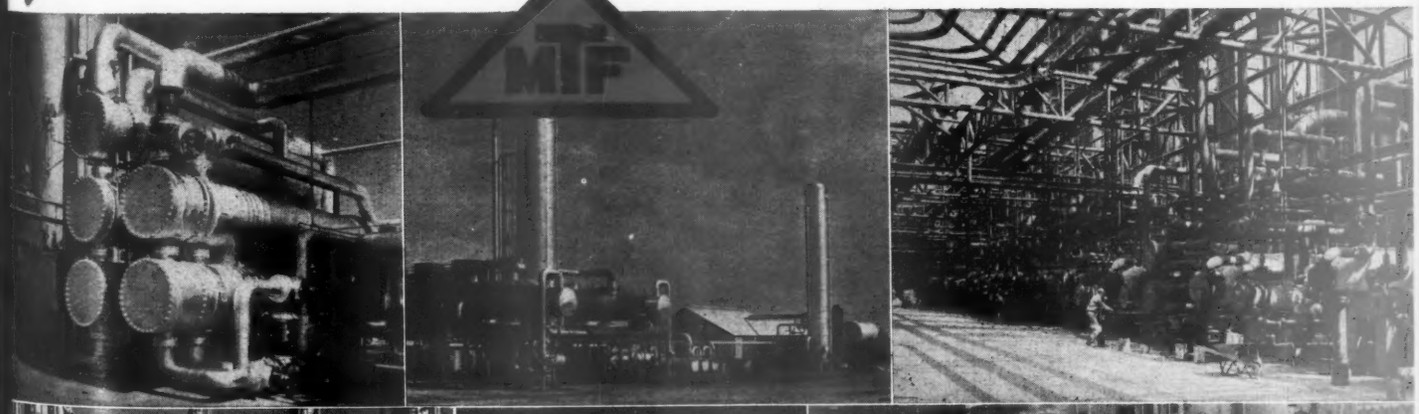

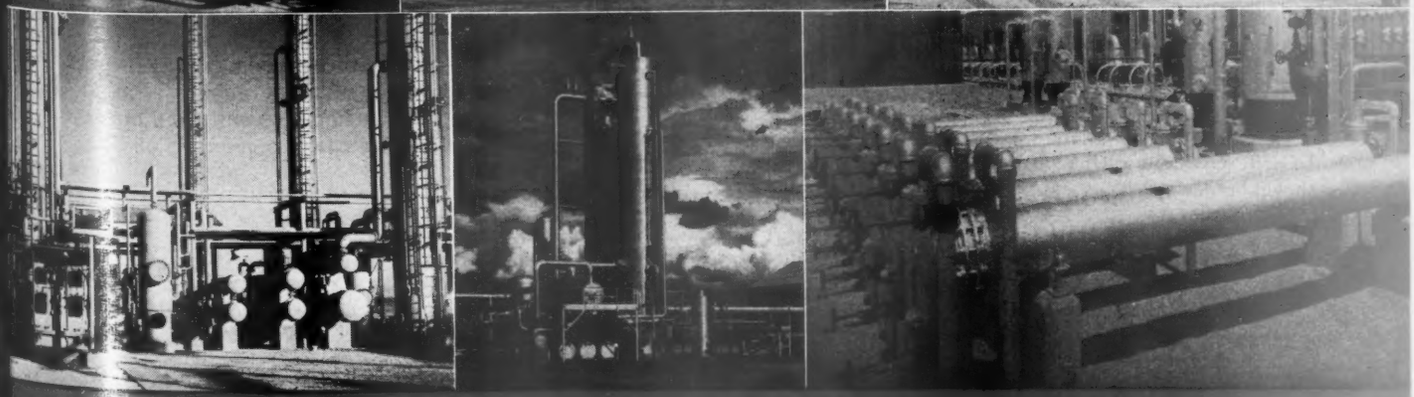

API-ASME and ASME Code Construction

$$V_1 = \frac{M_{AB} + M_{BA}}{L_1} = \frac{48205 + 79262}{30} = 4250 \text{ lb}$$

$$V_3 = \frac{M_{BD} + M_{DB}}{L_3} = \frac{27482 + 71785}{20} = 4960 \text{ lb}$$

$$H_2 = \frac{M_{BC} + M_{CB}}{L_2} = \frac{51780 + 68672}{10} = 12050 \text{ lb}$$

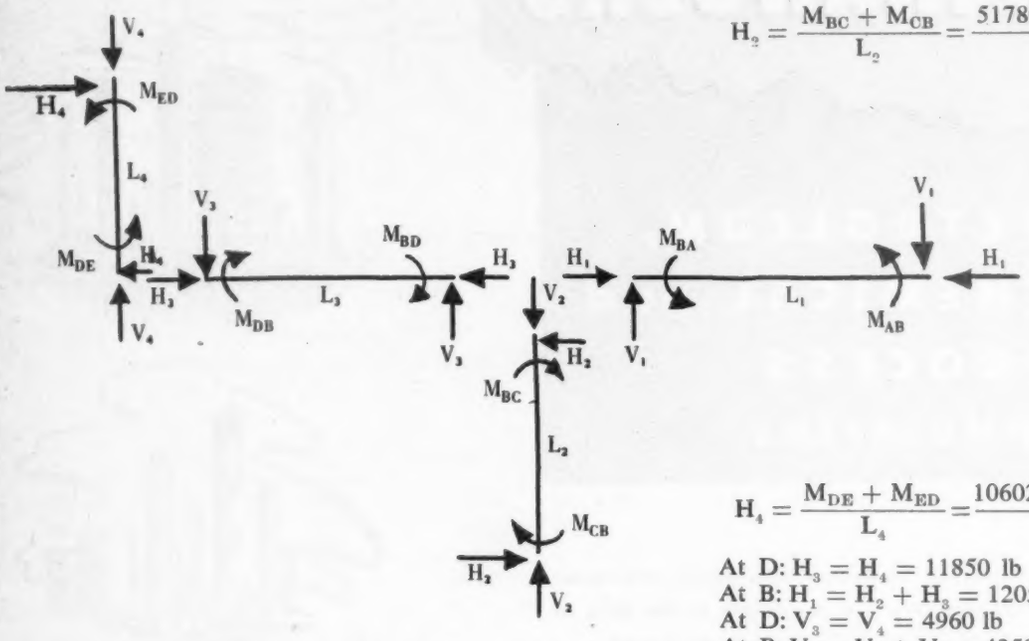

FIG. 7. Diagram of the laws of statics to determine reactions at the anchor and for better understanding of the sign convention.

$$H_4 = \frac{M_{DE} + M_{ED}}{L_4} = \frac{106022 + 71785}{15} = 11850 \text{ lb}$$

At D: $H_3 = H_4 = 11850$ lb
At B: $H_1 = H_2 + H_3 = 12050 + 11850 = 23900$ lb
At D: $V_3 = V_4 = 4960$ lb
At B: $V_2 = V_1 + V_3 = 4250 + 4960 = 9210$ lb
The reactions at the anchors are shown on Fig. 8.

The reader will note that how simple it is to solve the L-bend problem by the numerical method as given in Example 1. All the steps required involve nothing but one moment distribution and one "carry-over" operation. The real merit of the numerical method is not to solve the simple 2-anchor problems such as the I, U or Z bends, however, as there are dozens of ready-made charts or graphs available in trade catalogs or magazines to aid in a quick solution of these most elementary types of piping layout. The real merit lies in its ability to handle the multi-anchor piping layout, such as the 3-anchor problem in Example 2, without getting involved in any complicated mathematical theory or the tedious and time-consuming solution of simultaneous equations. It will also

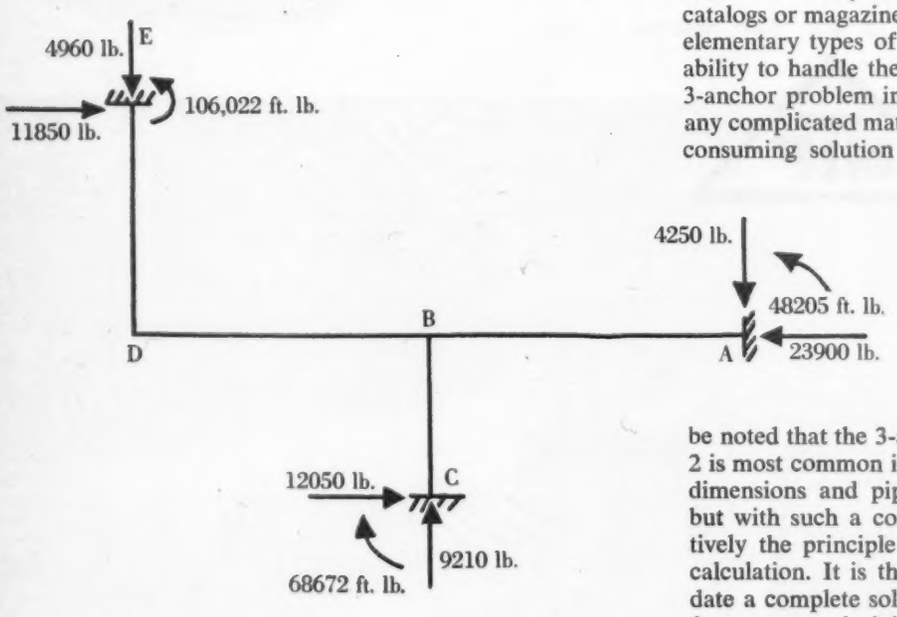

FIG. 8. Reactions at the anchors are found to be those shown here.

be noted that the 3-anchor configuration as given in Example 2 is most common in piping application. The run and branch dimensions and pipe sizes (Fig. 4) were chosen arbitrarily but with such a combination as to demonstrate most effectively the principle and procedure involved in a numerical calculation. It is the author's intention to publish at a later date a complete solution of 4-anchor problem taken directly from an actual piping layout for a two-stage crude oil distillation unit.

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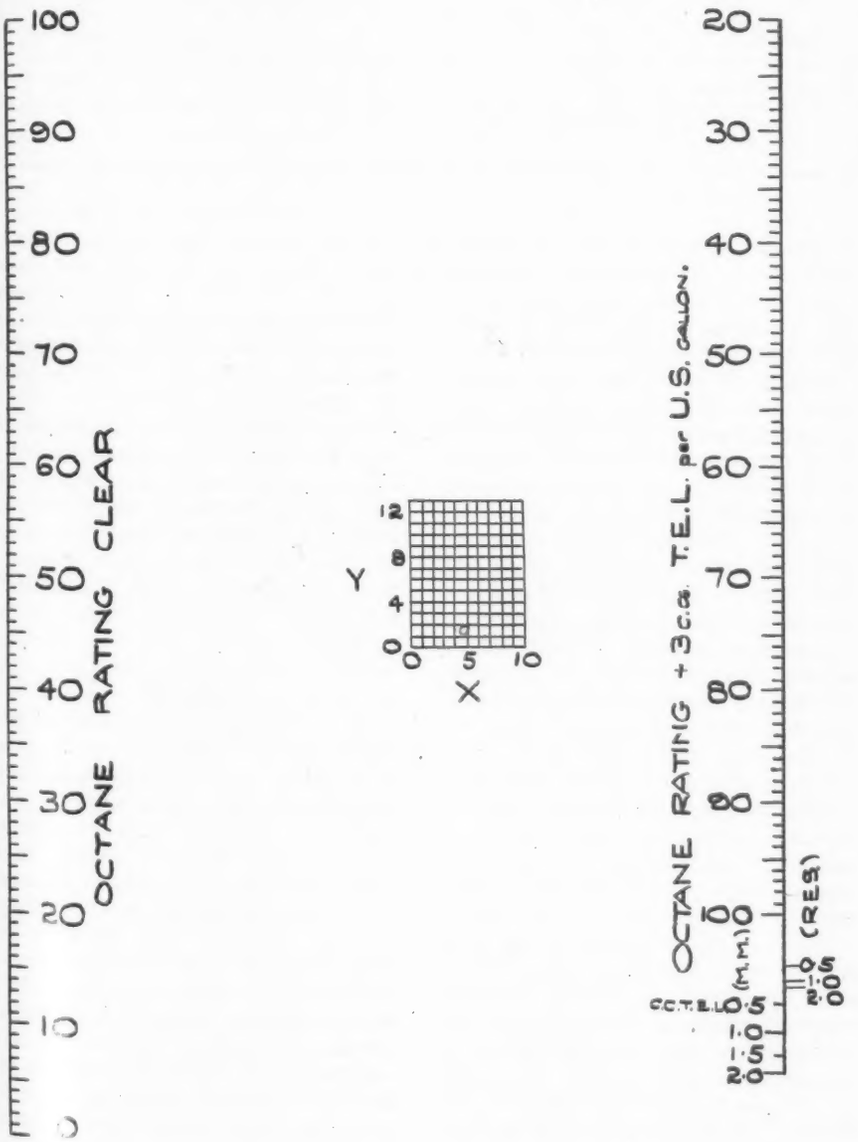
Lead Susceptibility of Hydrocarbons and Gasolines

George E. Mapstone



Nomograph for lead susceptibility of hydrocarbons and gasolines.

The lead susceptibility of gasoline is a function of the amounts and types of hydrocarbons present and of the amount and type of impurities, particularly sulfur compounds present. Maples[1] has recently shown that there are definite relationships between the clear and leaded (3 cc) octane ratings of the various classes of hydrocarbons. Although these relationships cannot be taken as exact or as applying to any particular sample of gasoline or hydrocarbon they prove most valuable when trends or average results are required.

This nomograph has been designed to present these relationships in a convenient and compact form. To use the chart, first locate the coordinates of the sample in the hatched area and then connect by means of a straight edge to the given octane rating (clear or leaded). The line will cut the other octane rating scale at the required value.

For example it is desired to estimate the Research octane rating of an average thermally reformed gasoline when leaded to 3 cc per gallon if the clear octane rating is 75 (Research). From the key the co-ordinates for the Research susceptibility of a thermally reformed gasoline are X = 5.3; Y = 5.6. Connecting this point by means of a straight edge with 75 on the clear octane rating scale (left hand scale) gives 87 leaded octane rating on the right hand scale.

Key, nomograph for lead susceptibility of hydrocarbons and gasolines.

Hydrocarbon or gasoline	Method	X	Y
Paraffins	Motor	6.9	1.0
Paraffins	Research	4.9	1.6
Naphthenes	Motor	5.0	4.8
Naphthenes	Research	1.7	6.8
Mono olefines	Motor	4.5	4.5
Mono olefines	Research	7.8	2.3
Cyclo olefines	Motor	3.4	12.1
Cyclo olefines	Research	0.1	12.5
Straight run	Motor	2.8	4.3
Straight run	Research	4.3	6.0
Catalytically reformed	Motor	8.0	4.1
Catalytically reformed	Research	7.1	3.1
Thermally reformed or cracked	Motor	6.9	6.5
Thermally reformed or cracked	Research	5.3	5.6
Catalytically cracked	Motor	8.3	6.7
Catalytically cracked	Research	6.3	5.0
Catalytically polymerized	Motor	7.1	8.1
Catalytically polymerized	Research	8.5	3.0

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Operating Experience With Amine Units for H_2S Removal

R. A. Feagan, H. L. Lawler, and M. H. Rahmes

SOUR natural gas must be treated for removal of hydrogen sulfide to produce marketable gas. The processes most widely used at the present time in the natural gas industry employ solutions of the ethanolamines. These are organic bases that have the property of reacting chemically with acidic gases at normal temperatures to effect their removal, but releasing them by decomposition of the amine salts at elevated temperatures. This property lends itself to a continuous process wherein sour gas is contacted at ordinary temperatures in one column by a circulating amine stream which is regenerated at the boiling point temperature and usually at lower pressure in a second column. Details of the process have been described adequately in the literature.[1, 2, 3, 4, 5] The process accomplishes essentially complete removal of carbon dioxide as well as hydrogen sulfide and will produce sweet gas which will meet readily the usual specifications of 0.25 gr H_2S per 100 CF.

The process may employ either monoethanolamine-water solutions for removal of hydrogen sulfide and carbon dioxide only or may employ a mixture of monoethanolamine, diethylene glycol, and water for simultaneous sweetening and dehydration. Diethanolamine solutions are sometimes employed, but find their principal application in refineries. The following discussion, however, deals solely with units employing MEA-H_2O solutions.

Much has been said and written about the design of H_2S removal units, and in recent years, a number of publications have discussed corrosion problems, particularly in amine-glycol systems.[6, 7, 8, 9] In spite of the relatively long time that amine units have seen commercial application — and in spite of a substantial research effort by the users, plant designers and manufacturers of amines and alloys — amine units continue to be a source of trouble and expense to many plant operators.

It is the purpose of this article to summarize briefly the tentative conclusions one company has reached based on four to five years' experience operating five H_2S removal units with aqueous monoethanolamine and on study of the experiences of other companies in this field. It must be emphasized that these conclusions regarding aqueous amine unit design and operation are tentative since all variables have not been sufficiently explored.

Presented before Natural Gasoline Association of America annual convention, Dallas, Texas.

The Authors

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M. H. Rahmes is senior process engineer for Stanolind in Tulsa. Rahmes joined the company in 1948 as a junior process engineer. He is a graduate of the University of Cincinnati and has a MS degree from Tulsa University.

R. A. Feagan, Jr.

H. L. Lawler

M. H. Rahmes

During 1953, the five H_2S removal units under discussion processed gas at a total average rate of 205,300,000 cu ft per day, and extracted acid gas (H_2S and CO_2) at a total average rate of 10,600,000 cu ft per day at a total cost (not including utilities, amortization, or overhead) of $808 per day, or about $76 per million cu ft of acid gas extracted. This expense can be roughly broken down as follows; maintenance, repairs, etc., 50 per cent; chemicals (primarily amine), 31 per cent, and operating labor, 19 per cent. Thus, the problems are, in the order of their importance, corrosion, amine losses, and frequency of operating upsets (such as foaming, failure to sweeten gas, etc.) calling for more operator attention and, consequently, higher operating labor costs.

Average gas processed by the five units during 1953 ranged from 8800 to 88,700,000 cu ft per day, acid gas removed ranged from an average of 330 to an average of 7,280,000 cu ft per day and total average operating cost ranged between $49 and $298 per million cu ft of acid gas removed. Design amine circulating rate for the five plants ranges between 97 and 1515 gal per minute, design gas handling capacity between 12 and 120,000,000 cu ft per day, design acid gas content between 0.9 and 24.5 per cent of the inlet gas. The units were designed and built by several different contractors, two of the plants feature "split flow" regeneration and one of these two is designed for "pressure" regeneration.

Costs mentioned above are substantially lower than those experienced during the early period of operation of these plants because of the numerous changes in design and operation made in some of the plants since start-up. Some of the costs reflect substantial expenditures for major repairs or revisions.

Corrosion

Corrosion has been experienced primarily in the reactivator reboilers, reactivators, solution pumps, heat exchangers and related piping. Reboiler life has ranged from two months to more than one year in the same plant, with the improvement credited to changes in design and operating practices. Carbon steel reboilers in other plants have lasted several years. One carbon steel reactivator tower has been completely replaced, two others repaired and modified after bubble cap trays were corroded away. A number of heat exchanger bundles have required repair or replacement while others have not failed to date.

All of the plants have experienced corrosion to some extent but, to date, the cost of corrosion in two of the

plants has been small. Amine losses have varied widely, foaming has been experienced at times, and there have been a few times that difficulty has been experienced in meeting sales gas specifications.

Recommendations

Obviously, time will not permit presentation of a detailed description of all operating experiences with these five units during the past four to five years. The brief descriptions above, however, were presented to indicate the type and scope of experiences upon which the following conclusions and recommendations have been based.

The following paragraphs will outline these conclusions and recommendations with a short discussion of each of them. As is so often the case, there must be a compromise, or economic balance, between initial investment and operating and maintenance costs. The authors do not have the data to draw this line precisely.

Some of the following suggestions may seem obvious but they are included to make the list as complete as possible. For convenience, recommendations are divided into two groups, (1) those that must be considered by the plant designer, and (2) suggestions for the plant operator. Following are the recommendations for the designer. He should:

1. Provide sufficient capacity to permit operating with low amine concentrations. Experience in the five plants discussed above has indicated a correlation between loading on the unit and corrosion troubles. The plants experiencing the least amount of corrosion have sufficient solution circulating capacity to permit satisfactory gas sweetening with amine concentration in the order of eight to ten per cent. Although it might not be economical to design a unit for such low solution concentration, it is recommended that a design concentration of 15 per cent MEA be used rather than the 20 to 30 per cent often proposed by investment-cost-conscious designers.

2. Avoid excessive reboiler heating medium temperatures. If steam is used for heating, excessive temperature is not usually a problem although there are indications that reboilers designed for relatively low heat flux, i.e., low pressure steam in the order of 50 to 75 psig, might have longer life than reboilers using high pressure steam. If other heat medium is used, such as hot oil, experience has shown that the problem can be critical. Both carbon steel and stainless steel reboiler bundles have failed in about 2 months when heated by oil entering at approximately 550 F. If hot oil is used, it is believed that the maximum temperature should be restricted to about 400 F[9] in an effort to limit amine film temperature. It should be recognized that even minor leaks may cause difficulties resulting from contamination of the solution by oil.

3. Avoid use of dissimilar metals. This applies particularly to regenerators and reboilers. Certain critical regenerator internals were constructed of stainless steel in one of the plants mentioned above. This caused serious bimetallic corrosion of the carbon steel shell at the point of contact. The same phenomenon has been experienced in hot amine lines (carbon steel) where some of the fittings were carbon-moly steel.

4. Give consideration to packed and lined regenerators rather than bubble tray towers. After encountering serious corrosion in several carbon steel towers equipped with carbon steel bubble trays, several of the regenerators in the five plants have been revamped, bubble cap trays removed, the regenerators lined with a two-inch sprayed cement mixture, and Raschig rings installed to replace the bubble cap trays. This system has proved satisfactory and has been adopted for new plant design.

5. Provide a suitable amine reclaimer. This is a small batch still operating on a slip stream amounting to one-half to one per cent of the design circulation rate. Its purpose is to remove from the circulating amine soluble but nonvolatile impurities such as decomposition and oxidation products of amine that are thought to contribute to corrosion. Usually a small amount of soda ash is added either directly to the reclaimer or to the circulating solution to accomplish more complete recovery of amine in the redistillation operation. Our experience indicates that amine redistillation is an important step in reducing corrosion. Decomposition of amine in the circulating system can be shown by comparing the results of several methods of analyses. Acid titration determines the total alkalinity, the Van Slyke indicates the primary amine group, and the Kjeldahl determines total nitrogen.

All these methods will give essentially identical MEA contents on a fresh solution. When decomposition begins or some reaction ties up or destroys the primary amine group, determinations by the three methods will begin to diverge. Another test used to indicate the corrosiveness of amine solution is the so-called "iron capacity test." In this test, the amine to be tested is contacted under certain specified and controlled conditions with powdered iron. The amount of iron dissolved is reported in parts per milion. To illustrate the effectiveness of amine reclaimers, results of tests on overhead and bottom streams from one reclaimer are shown in Table 1.

TABLE 1.

Determination	Feed	Bottoms	Overhead
Acid titration, as per cent MEA	17.5	45.1	19.5
Van Slyke, as per cent MEA	14.5	29.6	17.0
Kjeldahl, as per cent MEA	17.4	71.3	21.0
Iron capacity, ppm	47	1204	4

6. Provide an effective filter. In spite of all normal precautions, some corrosion takes place in amine systems. Corrosion products are in the circulating solution in the form of finely divided iron sulfide. This sludge has caused fouling of heat exchanger surfaces, plugging of some valves and lines, erosion of metal surfaces and even plugging of the regenerator and contactor columns. Several types of filters have been tested. It has been concluded that the precoated type filter using diatomaceous filter aid, although more expensive, is most satisfactory. It ordinarily operates on a slip stream from the hot rich amine to the regenerator.

7. Stress relieve major equipment. Stress relieving adds relatively little to the cost of equipment. Experience has shown that stress cracking is likely to occur in amine units, particularly where hot amine comes in contact with carbon steel that is not stress relieved. Some stress corrosion has been reported even in amine contactors. Consequently, the practice has been adopted of stress relieving all major items of equipment.

8. Design for lower reactivator operating pressure. Many amine units have been designed for "pressure regeneration" because higher operating pressure, in the range of 30 to 50 psig, increases the bottom temperature of the regenerator and is believed to result in more complete stripping of the solution, particularly with respect to CO_2. This improvement in stripping should permit designing for a larger acid gas pickup per gallon of solution circulated; therefore, reducing the design circulation rate. As experience is conflicting in this regard, there are indications that higher reactivator operating pressure increases reboiler, exchanger, and regenerator tower corrosion. Consequently, the practice has been adopted of designing for minimum reactivator pressure, the lower limit being set usually either by the pressure required to supply the acid gas to a sulfur plant or by the pressure required to force amine out of the regenerator through heat exchangers to a surge drum or pump suction.

9. Provide an efficient inlet scrubber to prevent liquid hydrocarbon from entering the amine contactor.

10. Design for low solution losses. Experience has shown that excessive solution losses are due to mechanical leakage or to amine entrainment. To combat this, solution pumps should be equipped with efficient mechanical seals, an efficient residue gas scrubber should be provided to recover amine entrained from the contactor, one or two water wash trays should be provided in the top section of the contactor and provision should be made to collect and reclaim any solution drained from equipment.

All designers know that even a well designed plant will not be satisfactory with careless or improper operation. In addition to following the more obvious measures to assure sweet gas, the operator should:

1. Use lowest amine solution strength that will give consistently sweet gas under the load conditions prevailing. This will reduce corrosiveness of the solution and will also reduce amine losses.

2. Establish and maintain effective reclaimer operation.

3. Establish and maintain effective filter operation.

4. Maintain equipment to prevent mechanical losses.

5. Operate the amine contactor with gas outlet temperature slightly higher than inlet temperature. This will prevent condensation of hydrocarbons in the contactor. Condensed hydrocarbons are believed to cause foaming and solution carryover. In some cases, foaming has been experienced even while this precaution was being observed. In these cases, it has been necessary to resort to a foam inhibitor such as octyl phenoxy ethanol.

The preceding discussion is not intended to present a complete list of problems which might be encountered during the design or operation of aqueous amine gas sweetening units, nor is it to be inferred that the above suggestions offer the optimum solution to any problem. Some of the suggestions apparently have solved satisfactorily some of the problems but in many cases the steps taken have only reduced the severity of the problem. Also, it is recognized that experience of other companies may have led them, with good reason, to different conclusions.

Conclusion

In formulating the above suggestions, the authors have had the benefit of the thoughts of a number of individuals in Stanolind Oil and Gas Company who are connected with the design and operation of amine units. The authors wish to express their appreciation to the management of Stanolind Oil and Gas for permission to present this paper.

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Largest Atom Smasher In Industry Purchased by Shell Development Company

A 3,000,000-volt particle accelerator—the most powerful radiation source available to industry—has been purchased for the Emeryville, California, research laboratory of Shell Development Company, Harold Gershinowitz, president, announced.

The unit, a Van de Graaff accelerator—sometimes called an "atom smasher" because it was originally used for nuclear research—will be the first of its size in the petroleum industry, and will be installed in June, 1956.

Shell scientists will use the accelerator in studying the effects of radiation on fuels, lubricants, plastics and other oil-derived products.

The machine produces a radiation field of extreme intensity, one several hundred times that of the most powerful radioactive cobalt source now used in industry.

Radiation produced by the accelerator is in the form of a high-intensity beam of electrons traveling at almost the speed of light. This beam is pinpointed to bombard a product, causing changes in its physical characteristics. It makes a plastic harder, increases its resistance to solvents and enables it to hold its shape at high temperatures.

With this powerful electron beam, Shell scientists hope to learn more about changes that take place in matter exposed to high energy radiation. Such information could lead to creation of new products.

The Van de Graaff accelerator, of which Shell will now own two, has two additional advantages over radioactive sources for industrial use: First, when turned off it presents no radiation hazard, whereas a cobalt source is always hazardous; and second, the accelerator is easily adapted to continuous production techniques such as conveyor belt treatment systems.

Shell's other accelerator, a two-million-volt machine, was installed in the company's Houston laboratory in September, 1954. Researchers use this machine in "aging" rocks atomically—by bombarding them with protons. The machine can reproduce in one week the amount of radio-activity to which a rock may have been exposed during ten million years in nature. Such studies can help scientists tell the age of rock formations and thus provide new clues in the search for oil.

The Houston machine is housed in a room with 2½-ft thick concrete walls, and an electrically operated nine-ton sliding door. A one-ton paraffin "shield" surrounds the target material. When the machine is in operation, no one is in the room. Closed circuit television shows what is going on inside.

REFINERY PLANTS SCHEDULED FOR COMPLETION

Isophthalic plant for California. A $7,000,000 plant for making isophthalic anhydride is being built for Standard Oil Company of California at Richmond, by H. K. Ferguson. Unit will make 50,000,000 lb of the product annually, to be consumed largely by the plastics and surface coatings industry. It is expected to be completed late this year.

★ ★ ★

Cat reformer for Sarnia. Imperial Oil will build a "platinum catalyst" reformer unit at its Sarnia, Ontario, refinery. Fluor Corporation of Canada, Ltd., will do the mechanical designing and construction, based on process design plans by Imperial's engineering staff. Unit will process 13,500 bbl daily of naphtha and is expected to be completed late in September, 1955.

★ ★ ★

Ammonia plant for Puerto Rico. Anhydrous ammonia, ammonium sulfate, and sulfuric acid will be manufactured by a new plant being built at Guanica, Puerto Rico for Gonzales Chemical Industries, Inc., of San Juan. Lummus Company of New York City is designing and building the plant, which will make 42,000 tons of ammonia annually. This is the first such unit for Puerto Rico.

★ ★ ★

Lube plant for Iraq. A complete lubricating oil plant for Iraq has been contracted for by that government, with Foster Wheeler Corporation, England, to produce 25,000 tons of lubricants annually. Units will include vacuum distillation, propane deasphalting, furfural solvent extraction, propane dewaxing, clay percolation, and acid treating, along with auxiliary equipment and facilities.

★ ★ ★

Canadian oil builds office. A new administration and protection building is to be built for Canadian Oil Companies, Ltd., at its Sarnia refinery. Designed by G. S. Adamson and Associates, Toronto, Ontario, it will be built by Con-Eng Contractors, Ltd., London, Ontario.

★ ★ ★

High octane unit slated by Aurora. Aurora Gasoline Company is installing the world's first UOP Rexforming unit, said to be capable of producing over 100-octane premium gasoline.

The company is expanding refining facilities at the Detroit refinery by converting an existing UOP Platforming unit to a Rexforming unit by addition of new octane extraction process which separates highest octane components from Platformate, returning the remainder to reactors of the Platforming unit for further upgrading.

The Rexformer will have a design capacity of 5500-bbl-per-day of fresh feed. It is the first to be licensed by Universal Oil Products Company since UOP recently announced the availability of this super-fuel producing process to the petroleum industry.

★ ★ ★

New refinery electrical system. A complete new electrical system has been built for Stanovan Refinery in British Columbia, Canada. It serves a crude unit, cat cracker, polymer and steam plants, and auxiliaries. Purchased power from Vancouver comes into a substation via two 12-kv circuits from a main substation a few miles away and is distributed all over the plant, which is about a mile from the distribution center. An emergency generator in the refinery is designed to serve only the cat cracker and the polymer plant.

★ ★ ★

Another delayed coker. American Oil Company, Standard of Indiana subsidiary, has decided on and is building a delayed coker unit at its Yorktown, Virginia, refinery to convert heavy residuals from crude and from cracking distillations to coke and intermediate (gas oil) type distillates suitable for thermal or catalytic cracking to motor fuel. This process, developed a quarter-century ago by R. E. (Bob) Wilson, now Standard's board chairman, is one of those now solving the problem of disposal and utilization of heavy residues, no longer required in great quantities for railroad locomotives and analogous uses.

★ ★ ★

More helium capacity to build. U. S. Bureau of Mines will build a $6,000,000 helium plant of 100,000,000 cu ft per year at Exell, Texas, where an older plant of 85,000,000 cu ft per year already is operating. Bids on the construction will be asked for shortly, it is stated. This unit will boost helium capacity to about 300,000,000 cu ft yearly and may enable the bureau to meet demands for 1959 or 1960. As of now, less essential uses of helium have been cut off, although the last fiscal year produced 212,000,000 cu ft.

Canadian platformer-unifiner on stream. The first combination of these two processes in a unit outside the United States went on stream recently at the McColl-Frontenac Oil Company refinery near Montreal, Quebec, Canada. Unit has 11,970 bbl per day capacity, the Unifiner being the feed preparation unit for the reformer, which will operate on fractions from Arabian and/or Venezuelan crudes Universal Oil Products Company, licensed and designed the units, and Procon, UOP construction-engineering subsidiary, built them.

★ ★ ★

Cat reformer for Continental. Invitations for bids on building a catalytic reformer at the Artesia, New Mexico, refinery of Continental Oil Company have been sent out. Nature of the process to be installed has not been disclosed. The unit is expected to be completed by about the first of January.

★ ★ ★

Rexformer for Cosden. Already operating a Platformer-Udex combination for making aviation blending fuel and aromatics, Cosden Petroleum Corporation has contracted with Universal Oil Products Company for a 3868-bbl-per-day Rexforming unit to meet demands for higher and higher octane rating motor and aviation fuels. The Platformer-Udex units will continue to make high purity aromatics. A five-tower prefractionation assembly will produce charge stock for these units. The Rexformer will be built by Procon, Inc. Cosden refinery staff is building a 1600-bbl Uniforming unit to be used to desulfurize a portion of the catalytic reforming units. The Rexformer will be finished by the spring of 1956, the Unifiner will be on stream "shortly."

Aerial view of the port at Aden, Arabia, of the British Petroleum Company's refinery (formerly Anglo-Iranian Oil Company), a plant of 100,000 bbl crude capacity per day, which processed more than 25,000,000 bbl in the last 12 months since going on stream. All crude was received at this port, which can accommodate four large tankers simultaneously. In the past year, 200 tankers discharged crude here, 130 loaded finished products.

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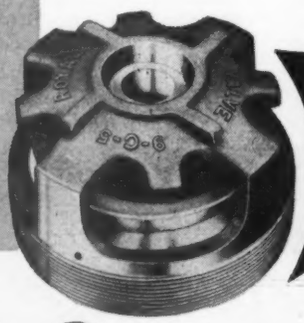

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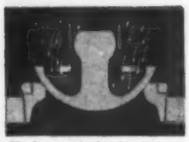

The free vertical action assures instant opening and closing. The ball stem is a frictionless guide.

Look at the drawings at the left and you will quickly see why Royal Crown Valves last longer and increase the efficiency and life of reciprocating pumps. Note that these valves are guided by a frictionless ball stem (not a rigid guide), which allows them to oscillate and turn with the fluid stream. They swing freely with each stroke of the pump — seating perfectly each time in a new position. There is a minimum of resistance to the fluid which results in greater pump volume at less pump speed. Simple construction means long trouble-free life. Write for details today.

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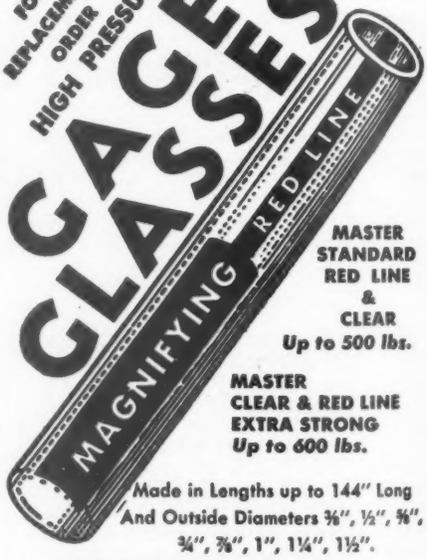

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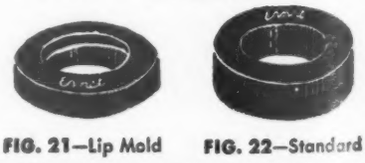

FIG. 21—Lip Mold **FIG. 22—Standard**

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Construction Report: 1955

Over 15,000 miles of pipe line built or underway
Nearly 20,000 miles of line planned or proposed

THE REALLY BIG NEWS IN THE PIPE line construction picture for 1955 is the work underway on a number of major gas pipe line projects that account for approximately one-half of the construction activity in the gas pipe line field.

Results of a comprehensive survey conducted by THE PETROLEUM ENGINEER for this annual October "Construction Issue" show that as of October 1, 1955, there were some 15,136 miles of crude, products, and gas pipe lines built or under construction during the preceding 12-month period.

Of this total, 8507 miles of gas pipe line account for more than half of the construction for the period. As predicted in THE PETROLEUM ENGINEER's 25th anniversary issue one year ago, the total mileage of products lines constructed or underway now leads the crude oil pipe line mileage. The PE survey shows there were 3655 miles of products lines built or underway as of October 1, and 2974 miles of crude lines built or underway.

Not included in the results are an estimated 1500 miles of small diameter gathering lines and some 12,000 miles of gas utility distribution lines.

The outlook for the next 12 months is as equally bright as that of the past year. PE's survey shows some 19,305 miles of crude, products, and gas lines on the books as being planned or proposed, and in the case of gas lines, a number of them approved by the FPC but not contracted, along with several now up awaiting hearings by the FPC with good chances for approval.

Leading the outlook list is a whopping total of 11,888 miles of gas pipe line, a lot of it in planned looping programs, followed by 3106 miles of crude lines and 4311 miles of products lines.

(A complete tabulation of planned and proposed pipe lines appears on pages D-23 and D-24, this issue. A complete tabulation of lines built or underway appears in tables on pages D-25, D-26, D-31, and D-32.)

A Petroleum Engineer Staff Report

Gas Line Construction

Two major gas pipe line projects — Pacific Northwest Pipe Line and the American Louisiana Pipe Line — got underway during the summer to highlight the activity in this phase of pipelining.

American Louisiana, which extends from south Louisiana to Detroit, Michigan, will lay a 1000-mile, 30-in. line plus 100 miles of 6 thru 24-in. lines. Some 500 miles of the system are expected to be laid during 1955.

Pacific Northwest got underway with awards of 1211 miles of line in five states to eight contractors. The first phase of the company's construction program calls for the main line, laterals, and gathering lines from Ignacio, Colorado to the Oregon-Washington border.

Tieing-in with the Pacific Northwest project is Colorado Interstate Gas Company's 380-mile, 22-in. line from Rock Springs to Denver.

Construction is underway on Texas Eastern's 377-mile, 30-in. line between Beaumont, Texas, and Kosciusko, Mississippi, whose capacity will replace the "Little Big Inch" and allow reconversion of that system to petroleum products. Texas Eastern is also adding over 125,000-hp to its compressor facilities.

Tennessee Gas Transmission Company's current expansion program consists of over 700 miles, including a 250-mile, 24-in. line from the Hebron, Pennsylvania storage field area to Greenwich, Connecticut, loops and laterals on the system, and a 370-mile, 30-in. line from Agua Dulce to Kinder, Louisiana that will skirt the Gulf Coast and tie-in at Kinder with a 576-mile, 30-in. built last year by TGT to Portland, Tennessee.

Transcontinental Gas Pipe Line is now nearing completion on a 600-mile looping program that saw first big-scale use of 36-in. pipe — over 300 miles — along with 230 miles of 30-in. on its system from Texas to the East Coast.

Texas Gas Transmission is winding up on a 200-mile looping and expansion program in Louisiana, Tennessee, Kentucky, and Indiana.

Other major projects include 76 miles of 26-in. loop by Atlantic Seaboard; a 238-mile program by Cities Service Gas Company including a 93-mile, 26-in. line between Blackwell, Oklahoma, and Independence, Kansas; a 200-mile expansion and looping program by Montana-Dakota Utilities; over 600 miles in new lines in the Panhandle and South Plains regions of Texas by Pioneer Natural Gas Company; the 350-mile Southeast Alabama Gas District undertaking, and the 300-mile South Georgia Natural Gas System.

Products Line Construction

Biggest news in the products pipe line field during 1955 is the construction of the 847-mile, 8, 12, and 16-in. Southern Pacific Pipe Lines, Inc., system between Los Angeles and El Paso. The first big products pipe line across New Mexico, Arizona, and California, and first of its type by a railroad company, the new system will operate in two directions — both ends will pump towards Phoenix from refineries in their respective areas.

The long discussed reconversion of the "Little Big Inch" pipe line from gas to products service is expected to get underway before long, most likely as soon as Texas Eastern Transmission Corporation completes its new gas facilities to replace the 16 and 20-in. line between Beaumont and the East. The project has FPC approval, and products — including LPG — are expected to be flowing in the line next year. Capacity of over 250,000 bbl

per day is planned for the reconverted line.

Also making the headlines was the inauguration of service on the products end of the 2262-mile Cherokee Pipe Line system. *(see article on page D-40, this issue).*

Other major products line projects during the past year include completion of the 200-mile Badger Pipe Line system in the Chicago and Milwaukee areas; Buckeye Pipe Line's current conversion of a 266-mile, 8-in. crude line to products service between Toledo, Ohio, Cleveland, Ohio, and Huntington, Indiana; Great Lakes Pipe Line's projects which included a 106-mile, 12-in. loop between Des Moines and Iowa City, Iowa, a 163-mile, 10-in, line from El Dorado, Kansas, to Kansas City, Missouri, and a 132-mile, 8-in. extension from Nebraska City to Doniphan, Nebraska; Inland Corporation's 88-mile, 10-in. line between Toledo and Lima, Ohio; Magnolia Pipe Line's conversion of 193 miles of 8-in. to LPG service, and 177 miles — including 9 miles of new line — of 8-in. between Beaumont and Waskom, Texas to products service; Shell Pipe Line's 65-mile, 12-in. line from Norco to Baton Rouge, Louisiana, and Shamrock Pipe Line's 102 mile, 6-in. line between Amarillo and Abernathy, Texas.

Other projects include Okan Pipe Line's 353-mile natural gasoline and LPG system from western Kansas to Tulsa; the 235-mile, 8-in. Oil Basin Pipe Line between Laurel and Glendive, Montana; the 248-mile, 6 and 8-in. Standard Pipe Line System between El Paso and Albuquerque; and the 96-mile, 5-in. LPG system between Provident City and Texas City, Texas, built by Products Pipe Line Company.

Crude Line Construction

Longest of the lines under construction is the 447-mile 10, 12, and 16-in. Butte Pipe Line between Poplar, Montana and Guernsey and Ft. Laramie, Wyoming. This new system, a joint venture of Shell Oil Company, the Murphy Corporation, and others, will carry crude from eastern Montana and the western end of the Williston Basin to connections with Service Pipe Line and Platte Pipe Line for delivery to Chicago or Wood River.

Other major projects underway or recently completed include the 256-mile, 16-in. Minnesota Pipe Line from Clearbrook — on the Interprovincial Pipe Line system — to St. Paul-Minneapolis, Minnesota; 217 miles of 12, 14, and 16-in. loop lines by Magnolia Pipe Line Company on its Midland to Corsicana, Texas system; the 106 mile, 12 and 16-in. Peace River Oil Pipe Line, between Valleyview (Sturgeon Lake Field) and the Edson station on the Trans Mountain Pipe Line; a 78-mile, 6-in. line from Sumatra pool in central Montana to Billings, built by Art Hartwig, Inc.; 125 miles of lines in the Pembina field by Pembina Pipe Line, Ltd., and a 31-mile line between Dayton and Sour Lake, Texas.

Major projects completed in the past 12 months also include the 477-mile, 18 and 20-in. Arapahoe Pipe Line between Merino, Colorado, and Humboldt, Kansas; Service Pipe Line's 625-mile, 20, 22, and 24-in. line from Ft. Laramie, Wyoming to Freeman, Missouri; the 154-mile, 16-in. South Saskatchewan Pipe Line between Cantuar and Regina; Union Oil Company's 67-mile, 12-in. line in California, and 74 miles of 5 to 10-in. in west Texas by Texas-New Mexico Pipe Line Company.

Looking Ahead

Included in the nearly 20,000 miles listed under "Proposed or Planned Pipe Lines" in the tables on pages D-23 and D-24 of this issue are some very large projects whose construction has been delayed for a variety of reasons. The outlook for many of these projects, is very good; construction of some, however, must be considered doubtful.

Gas Lines. If the many parties to plans centering around the building of the Trans Canada Pipe Line find a common meeting ground, this vast system and its related projects will give the pipe line construction industry a big boost.

Among the latest proposals in connection with the 2247-mile Trans Canada line is a plan advanced by Tennessee Gas Transmission Company to build a 1050-mile line from Emerson, Manitoba—on the U. S.-Canadian border—southward to Nashville, Tennessee. Part of the gas would be delivered back into Canada near Niagara Falls for service to Toronto and eastern Canadian cities.

This plan would allow Trans Canada to finance and build the western end of its system and parts of the eastern end. As markets developed, the company could then build the middle portion of the system on an all-Canadian route.

Northern Natural Gas Company has delayed its plans to buy gas from Trans Canada, but is reported still interested in also taking gas at Emerson for delivery into its midwestern area markets.

Construction of the 315-mile Alberta Gas Trunkline, gathering system in Alberta must also wait until some type of plan is finalized on the Canadian line.

In Western Canada, construction on the 670-mile, 30-in. Westcoast Transmission Company pipe line is pending approval by FPC on gas import plans of the Pacific Northwest Pipe Line. If the proposal gets a green light, Westcoast will most likely begin some work this winter or in early spring.

Construction on the final phase of Pacific Northwest is also dependent on the FPC hearings to import gas. Another 500 miles of main line and laterals remain uncontracted.

Also related to with the Pacific Northwest-Westcoast plans are the plans of El Paso Natural Gas to supply additional gas to northern California. The company is considering several alternatives including a 330-mile, 34-in. loop of its San Juan-Topock system, and a 370-mile line from Mountain Home, Idaho station of Pacific Northwest to near Reno, Nevada.

Another 1600 miles of gas line may result from plans of two companies. Houston Texas Gas and Oil Company —which has proposed several different large-scale projects in recent years— has applied to the FPC for a permit to construct a 961-mile system from Baton Rouge, Louisiana to Miami, Florida. Allied with the plan is a proposal by Coastal Transmission Company to bring gas from the Gulf Coast of Texas to Baton Rouge via a 550-mile system from McAllen, Texas.

Products Lines. Reconversion of the "Little Big Inch" by Texas Eastern Transmission must be considered a sure thing, now that the firm has FPC approval for building alternate gas facilities and has them under construction.

As a result, it is unlikely that American Pipe Line Company's plans for a new 1910-mile produtcs system from the same Beaumont, Texas area to Newark, New Jersey will be built. There is little need at present, if any, for duplicate systems.

The outlook listing shows a number of smaller projects proposed, most of them 200 miles in length or shorter. Also included are a number of projects involving the conversion of existing crude lines to products or LPG service.

Crude Lines. No big new crude line projects have been announced recently that are likely to be built in the next year. Construction activity in this field of pipelining at this time appears to be the lowest in years. Much of this, however, can be accounted for by the fact that the influx of gas pipe line construction activity has kept many companies from embarking on programs because the pipe line contracting firms are loaded with work—and there is only so much equipment available to do the work.

Answers to THE PETROLEUM ENGINEER's survey revealed, however, that many companies are considering expansion, looping, and replacement of lines and that much of this work will commence in 1956. The outlook here is not bleak—the projects are merely being delayed. * * *

Proposed or Planned Pipe Lines

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects —crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

Name of Company	Miles	Size	Location
Ar-Mex Pipeline Company, Dallas, Texas	790	12–14	Guernsey, Wyoming to Coolidge, Arizona
Arapahoe Pipe Line Company, Merino, Colorado	41	10–12	Kimball County, Nebraska to Merino, Colorado
Big Horn Pipe Line Company, Cheyenne, Wyoming	150	8	Ash Creek field to Service Pipe Line Company connection
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
Michi, Inc., Detroit, Michigan	222	10	Highland Indiana to Alma, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to Mc Pherson, Kansas
Peace River Oil Pipe Line, Ltd., Edmonton, Alberta	37	4–8	Gathering system in Sturgeon Lake and Little Smoky fields
Pasotex Pipe Line Company, El Paso, Texas	68	20	Loop on Wink-El Paso system
Powder River Pipe Line Company, Casper Wyoming	436	10–16	Williston Basin to Laurel-Billings, Montana, refining area
Richfield Oil Corporation, Los Angeles, California	4	10	Lines in Los Angeles area
Salt Lake Pipe Line Company, Salt Lake City, Utah	82	10	Loops on line from Rangley, Colorado to Salt Lake City
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon, Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3–6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	21.2 815	6–12 —	New crude line additions in California Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles

PRODUCTS LINES

Name of Company	Miles	Size	Location
American Pipe Line Company. New York, New York	1910	8–26	Beaumont, Texas to Newark, New Jersey
Ar-Mex Pipe Line Company, Dallas, Texas	60 70	8 8	Coolidge to Phoenix, Arizona Coolidge to Tuscon, Arizona
Bell Oil and Gas Company, Tulsa, Oklahoma	140	6–8	Ardmore to Cushing, Oklahoma
California-Oregon Pipe Line System, Cresecent City, California	103	6	Crescent City, California to Medford, Oregon
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U.S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
Freedom-Valvoline Oil Company	13 70	6 6–8	Cooks Ferry to Freedom, Pennsylvania Conversion of existing crude lines from Cooks Ferry to Canton, Ohio
International Pipe Line, Inc., Minneapolis, Minnesota	132	8	Wrenshall to Minneapolis, Minnesota
Inland Corporation	5 34 15	8 10 10	Lines in Cleveland, Ohio area Cleveland to Mogadore, Ohio Fostoria to Tiffin, Ohio
Magnolia Pipe Line Company, Dallas, Texas (LPG Line) (LPG Line)	214 240	8 10	Midland to DeLeon, Texas (Converting existing crude line) Corsicana to Beaumont, Texas (Converting existing crude line)
Malco Pipe Line, Inc., Roswell, New Mexico	91 138	6 6	Prewitt to Albuquerque, New Mexico Artesia to Newman, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana to Minot, North Dakota
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Standard Oil Company (Ohio) c/o Sohio Pipe Line Company, St. Louis, Missouri	35.5	6	Mogadore to Girad, Ohio
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16–20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia upon completion of new gas facilities. Has FPC approval to abandon gas service from the "Little Inch."
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U.S.-Canadian border to Winnipeg (See also Deep Rock Gas Company listing)

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6–34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
American Louisiana Pipe Line Company, Detroit, Michigan	117	22	Defiance, Ohio, to Bridgman, Michigan
Arkansas-Louisiana Gas Company, Shreveport, Louisiana	76	24	Loops in Louisiana
Carolina Natural Gas Corporation	185	2–12	Lines in North and South Carolinas
Central Hudson Gas & Electric Corporation, Albany, New York	48	12	Albany to Kingston, New York
Coastal Transmission Corporation, Dallas, Texas	550	30	McAllen, Texas to Baton Rouge, Louisiana
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6–8	Julesburg area to Denver, Colorado
El Paso Natural Gas Company, El Paso, Texas	370	—	Mountain Home, Idaho to near Reno, Nevada
	330	34	Farmington, New Mexico to Topock, Arizona
	36.3	12	Pampa to Dumas, Texas
	22.8	26	Loop near Gila, Arizona
	62	14	Midland to Coke County, Texas
Houston Texas Gas & Oil Company, Houston, Texas	961	12–20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	252	4–24	Loops on system in Missouri, Iowa, Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Mississippi River Fuel Corporation, St. Louis, Missouri	190	10–18	Laterals in Texas
Morganfield Natural Gas Company	31	4–6	New lines in Kentucky
Natural Gas Pipe Line Company of America, Chicago, Illinois	350	20–26	Amarillo, Texas to Wise County, Texas, through Southwest Oklahoma
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
North Canadian Oils, Ltd.	140	—	Wabuman to Hinton, Alberta
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10–12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnseota, Iowa, and Wisconsin
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Pacific Gas & Electric, San Francisco, California	190	34	Loops on Topock, Arizona to Milpitas, California, system
Panhandle Eastern Pipe Line Company, Kansas City, Missouri	58	16	Peoria to Springfield, Illinois
	20	24	Rolla to Hugoton, Kansas
	74	4–16	Loop lines and replacements on system
Pioneer Natural Gas Company, Amarillo, Texas	261	3–22	New lines, loops, replacements and irrigation feeder lines Panhandle and South Plains of Texas
Pine Tree Natural Gas Company	204	—	Boston, Massachusetts to Bangor, Maine
Shenandoah Gas Company, Winchester, Virginia	39	3–8	Middleton, Virginia to Martinsburg, West Virginia
Southern Natural Gas Company, Birmingham, Alabama	39	—	Loops on system
Tennessee Gas Transmission Company, Houston, Texas	221	26–30	Loops in Ohio and Kentucky
	1050	—	Emerson, Manitoba to Nashville, Tennessee, through Minnesota, Wisconsin, Illinois, Indiana, and Kentucky
	376	6–24	Gathering lines in Texas and Louisiana
Texas Gas Transmission Corporation, Owensboro, Kentucky	105	10–12	Eunice to Morgan City, Louisiana
	81	8–30	Loops on system
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14–34	Alberta area to Toronto, Montreal, and other eastern Canada areas
Trunkline Gas Company, Houston, Texas	24	—	Lines in Texas
Union Gas Company of Canada	180	—	Dawn Storage Field to Hamilton, Ontario
United Gas Pipe Line Company, Shreveport, Louisiana	63	—	Additions to system in Mississippi, Alabama, and Florida
United Natural Gas Company	50	12	Elk county to Jefferson county, Pennsylvania
Utah Natural Gas Company, Salt Lake City, Utah	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia
Westcoast Transmission Company, Ltd., Calgary, Alberta	670	30	Peace River Area of Alberta to Vancouver and U.S.-Canadian border (for delivery to Pacific Northwest Pipe Line Company)

Lines Built or Underway

The following tables list details on crude, products, and gas lines built or under construction in the 12-month period ending October 1, 1955, as reported to The Petroleum Engineer.

CRUDE LINES

Name of Company	Miles	Size	Location	Date completed	Contractor
Arkansas Pipe Line Corporation, Shreveport, Louisiana	3.89	Var.	Gathering lines in Arkansas and Louisiana	1955	Company, local contractors
Arapahoe Pipe Line Company, c/o Sinclair Pipe Line Co., Independence, Kansas	477	18–20	Merino, Colorado to Humboldt, Kansas	11–54	R. H. Fulton and Company Panama-Williams Corp.
Artesia Pipe Line Company, Roswell, New Mexico	30	4	Eddy county to Chaves county, New Mexico	1955	Company
Buckeye Pipe Line Company, Lima, Ohio	15	10	Wayne to Detroit, Michigan	11–55	H. L. Gentry Construction Co.
Butte Pipe Line Company, c/o Shell Pipe Line Corp., Houston, Texas	447	10–12–16	Poplar, Montana to Guernsey, Wyoming	10–55	O. R. Burden Construction Associated Pipe Line Contractors Anderson Bros. Corp.
Cherokee Pipe Line Company, (Crude Lines) c/o Cities Service Pipe Line Company, Bartlesville, Oklahoma	22.9	8	Hewitt station to Tussy station, Carter county, Oklahoma	11–54	W. H. Smith Const. Co.
	4	6–8	Garvin County, Oklahoma	11–54	Pipeline Service Company
Cities Service Pipe Line Company, Bartlesville, Oklahoma	10.3	4	Ector County, Texas	7–55	M. L. Moore Const. Co.
	4.8	8	Kay County, Oklahoma	8–55	B & B Contracting Co.
Continental Pipe Line Company, Ponca City, Oklahoma	65	12	Tonkawa to Oklahoma City, Okla.	11–54	G. G. Griffis
	24	8	Guernsey, Wyoming to Horse Creek station, Wyoming	UC	G. G. Griffis
Cooperative Refinery Association, Kansas City, Missouri	5	4	Additions to gathering system	1955	—
Derby Refining Company, Wichita, Kansas	5	4	Additions to gathering system	1955	Mitchell Construction Co.
Imperial Pipe Line Co., Ltd., Edmonton, Alberta	6	Var.	Additions to gathering system	1955	Various
Interstate Oil Pipe Line Company, Shreveport, Louisiana	32.4	8	Gwinville field to Soso, Mississippi	11–54	Houston Contracting Co.
	9.6	4	Bee Brake field to main line	11–54	Campbell Weld. Works
	13.3	16	Little Lake to LaRose, Louisiana	8–55	Sam Carline
	5.3	16	Port Allen to Anchorage, Louisiana	9–55	L. E. Farley
	19	4–12	Lines in Plaquemine Parish, La.	UC	Horton-Schoolcraft Company
Magnolia Pipe Line Company, Dallas, Texas	217	12–14–16	Fill-in of existing loops, Midland to Corsicana, Texas	7–55	H. B. Zachry Company O. R. Burden
Magnolia-Conoco-Newmont	48	13	Offshore line in Gulf of Mexico	1955	Brown and Root, Inc.
Mid-Continent Pipe Line Company, Tulsa, Oklahoma	35	8	Osage county, Oklahoma to Sand Springs, Oklahoma	9–55	—
Minnesota Pipe Line Company, St. Paul, Minnesota	256	16	Clearbrook to Pine Bend, Minn.	8–55	Williams Brothers
	3	16	Cottage Grove to St. Paul, Minn.	9–55	Williams Brothers
Ohio Oil Company, Findlay, Ohio	11.5	12	Zionsville, Indiana to main 22 in. line	9–55	H. L. Gentry Company
Pasotex Pipe Line Company, El Paso, Tex.	68	20	Loops on Wink to El Paso Line	—	No contract let
Peace River Oil Pipe Line, Ltd., Calgary, Alberta	106	12–16	Edson, Alberta to Valleyview	UC	Fulton-Banister
Pembina Pipe Line, Ltd., Calgary, Alberta	70	16	Pembina field to Edmonton	12–54	Sparling-Davis
	125	3–16	Pembina field gathering lines	1955	Sparling-Davis
Phillips Pipe Line Co., Bartlesville, Okla.	7.5	6	Rankin to Benedum, Texas	9–55	—
Platte Pipe Line Co., Kansas City, Missouri	8.1	6	Gebo to Chatham, Wyoming	12–54	A. J. Curtis Company
Power River Basin Pipeline Company, Billings, Montana	78	6	Sumatra pool to Billings	9–55	—
Richfield Oil Corp., Los Angles, Calif.	8	6	Vinvale to Los Angeles, Calif.	8–55	Engineers Ltd.
Shell Oil Company, Los Angeles, Calif.	11	8	Brea to Sante Fe Springs, Calif.	11–54	Engineers Ltd.
Sinclair Pipe Line Company, Independence, Kansas	9.2	8	Best station to Moran Junction, (near Whitesboro, Texas)	12–54	May and Taylor
	31.4	12	Sour Lake to Dayton, Texas	9–55	Gray-Morrison Company
Service Pipe Line Company, Tulsa, Oklahoma	625	20–24	Ft. Laramie, Wyoming to Freeman, Missouri	12–54	H. B. Zachry Company O. R. Burden
Skelly Oil Company, Tulsa, Oklahoma	43.5	12	El Dorado to Burrton, Kansas (Loop line)	5–55	Gronninger and King
	14	6	Reno and Kingman counties, Kansas	1955	—
South Saskatchewan Pipe Line Company, Regina, Saskatchewan	154	16	Cantuar to Regina	12–54	Fulton-Banister
	13	8	Fosterton-Cantuar are to Battrum field	UC	—
Sohio Pipe Line Co., St Louis, Missouri	15	8	Eldorado to Enfield, Illinois	8–55	L. R. Young

Name of Company	Miles	Size	Location	Date completed	Contractor
Texas-New Mexico Pipe Line Company, Houston, Texas	74	5–10	Maljamar, New Mexico to Midland, Texas	1955	McVean and Barlow Co. Ferguson Construction Co.
Trans Mountain Oil Pipe Line Corporation, Vancouver, British Columbia	36.5	16–20	Laurel to Anacortes, Washington	7–55	Engineers Ltd.
Trans Prairie Pipelines, Ltd., Winnipeg, Manitoba	25	3–4–6	Gathering systems in Manitoba	1955	—
Union Oil Company of California, Los Angeles, California	67 60	12 4–12	Piru to Los Angeles, California Additions to system and gathering lines	5–55 1954–55	Engineers Ltd. Various

PRODUCTS LINES

APCO Products Pipeline Co., c/o Anderson-Prichard Co., Oklahoma City, Okla.	30	4	Cyril to Duncan, Oklahoma	1955	—
Badger Pipe Line Company, Des Plaines, Illinois	181	12	East Chicago, Indiana to Madison, Wisconsin	1–55	Contracting and Material Co. Mid-States Construction Co. Morrison Construction Co.
	18	10	Lemont to Harlem Avenue, Illinois	6–55	Contracting and Material Co. Morrision Construction Co.
Buckeye Pipe Line Company, Lima, Ohio	78 266	8 8	Lima to Columbus, Ohio Toledo, Ohio to Cleveland, Ohio and Huntington, Indiana (conversion of existing line)	12–54 10–55	Sheehan Pipe Line Constr. Co. Sheehan
Cherokee Pipe Line Co., (Products Lines) c/o Continental Pipe Line Company, Ponca City, Oklahoma	31	6–8–10	New lines to connect existing lines to complete system	1954	Various
Champlin Pipe Line Company, Enid Oklahoma	81 46	6 6	Enid to Oklahoma City, Oklahoma Enid to Ponca City, Oklahoma	2–55 8–55	River Construction Corp. River Construction Corp.
Great nLakes Pipe Line Company, Kansas City, Missouri	106 163	12 10	Des Moines to Iowa City, Iowa El Dorado, Kansas to Kansas City	UC 1955	M-R Company Ray L. Smith and Sons M-R Company
	132	8	Doniphan to Nebraska City, Nebr.	1954	R. H. Fulton and Company
Inland Corporation, c/o Sohio Pipe Line, St. Louis, Missouri	88.7	10	Toledo to Lima, Ohio	2–55	Somerville Construction Co. Fulghum Construction Co.
Kaneb Pipe Line Company, Houston, Tex.	1.17	6	Wichita to Bareco tank farm	1954	Johnson
Keystone Pipe Line Company, Philadelphia, Pa.	49 2	8 8	Westchester to Allentown, Pa. Woodlyn to Swarthmore, Pa.	9–55 9–55	Sheehan Pipe Line Constr. Co. Sheehan Pipe Line Cons r. Co.
Magnolia Pipe Line Company, Dallas Texas	177	8	Beaumont to Waskom, Texas (9 miles new line, balance is reconditioned existing crude line)	3–55	H. B. Zachry Company Company Personnel
	123	8	Corsicana to DeLeon, Texas (Re-condition existing crude line for LPG service)	UC	Company Personnel
	70	8	Beaumont to Hull, Texas (Recondi-tion existing crude line for LPG service)	11–54	H. B. Zachry Company
Oil Basin Pipe Line Co., Billings, Montana	235	8	Laurel to Glendive, Montana	12–54	Midwestern Constructors
Okan Pipe Line Company, Tulsa, Oklahoma	353	4–6	Tulsa, Oklahoma to Liberal, Kansas	8–55	Vaughn and Taylor R. H. Fulton and Company
Phillips Pipe Line Company, Bartlesville, Oklahoma	67.5	10	Benedum to Sweeny, Texas (Natural Gasoline line)	6–55	—
	5	8	Lines in Missouri	UC	—
	17	6	Abernathy to Lubbock, Texas	UC	—
Products Pipe Line Co., Houston, Texas	96	5	Provident City to Texas City, Texas	1955	Panama Williams Corporation
Shamrock Pipe Line Corp., Amarillo, Texas	102	6	Amarillo to Abernathy, Texas	4–55	Arey Construction Co.
Shell Pipe Line Corp., Houston, Texas	65	12	Norco to Baton Rouge, Louisiana	6–55	Houston Contracting Co.
Sinclair Pipe Line Co., Independence, Kansas	16.5	6	Ft. Worth to Arlington, Texas	5–55	Altgelt Construction Co.
Socony-Mobil Oil Co., Inc., Wichita, Kansas	13	6	Near St. Paul, Minnesota	9–55	Underground Constructors
Socony-Mobil Oil Co., Inc., Eastern Division, New York, New York	5	12	Staten Island, New York to Linden, New Jersey	7–55	Hallen Construction Co.
Standard Oil Co. (Indiana), Chicago, Illinois	37	8	Chicago to Manhattan, Illinois (17 miles new line, 20 miles converted crude line)	1–55	Midwestern Construction
	114	8	Wichita to Humboldt, Kansas (108 miles converted crude line, 6 miles new line)	8–55	M-R Company
Standard Pipe Line Company, c/o Salt Lake Pipe Line Co., Salt Lake City, Utah	248	6–8	El Paso, Texas to Albequrque, New Mexico	1955	Houston Contracting Company

CONSTRUCTION REPORT: 1955

Lines Built or Under

This map shows lines completed or under construction as
as reported in The Petroleum Engineer's annua

Key to Map

CRUDE LINES

1. Arapahoe Pipe Line Company
2. Butte Pipe Line Company
3. Continental Pipe Line Company
4. Magnolia Pipe Line Company
5. Magnolia-Newmont-Conoco
6. Minnesota Pipe Line Company
7. Pasotex Pipe Line Company
8. Powder River Basin Pipe Line Company
9. Service Pipe Line Company
10. South Saskatchewan Pipe Line Company
11. Texas-New Mexico Pipe Line Company
12. Trans Mountain Oil Pipe Line Corporation
13. Union Oil Company of California
14. Peace River Oil Pipe Line, Ltd.

PRODUCTS LINES

15. Badger Pipe Line Company
16. Buckeye Pipe Line Company
17. Champlin Pipe Line Company
17-A. Great Lakes Pipe Line Company
17. Inland Corporation
19. Keystone Pipe Line Company
20. Magnolia Pipe Line Company
21. Oil Basin Pipe Line Company
22. Okan Pipe Line Company
23. Products Pipe Line Company
24. Shamrock Pipe Line Corporation
25. Shell Pipe Line Corporation
26. Sinclair Pipe Line Company
27. Socony-Mobil Oil Company, Inc.
28. Socony-Mobil Oil Company, Inc., Eastern Lines
29. Standard Oil Company (Indiana)
30. Standard Pipe Line Company
31. Southern Pacific Pipe Lines, Inc.
32. Texaco-Cities Service Pipe Line Company
33. Union Oil Company of California

GAS LINES

34. Alabama-Tennessee Natural Gas Company
35. American Louisiana Pipe Line Company
36. Atlantic Seaboard Corporation
37. Canadian Western Natural Gas Company, Ltd.
38. Cities Service Gas Company
39. Colorado Interstate Gas Company
40. Colorado Wyoming Gas Company
40-A. East Ohio Gas Company
42. Montana Dakota Utilities Company
43. Montana Power Company
44. Northern Natural Gas Company
45. Pacific Gas & Electric
46. Panhandle Eastern Pipe Line Company
47. Phillips Petroleum Company
48. Pioneer Natural Gas Company
49. Southern Counties Gas Company
50. South Georgia Natural Gas Company
51. Southeast Alabama Gas District
52. Texas Eastern Transmission Corporation
53. Texas Eastern-Penn Jersey Transmission Corporation
54. Wilcox Trend Gathering System, Inc.
55. Tennessee Gas Transmission Company
56. Texas Gas Transmission Corporation
57. Transok Pipe Lone Company
58. Transcontinental Gas Pipe Line Co.

TION REPORT: 1955

Lines Built or Un

This map shows lines completed or under construc
as reported in The Petroleum Engineer'

· Underway

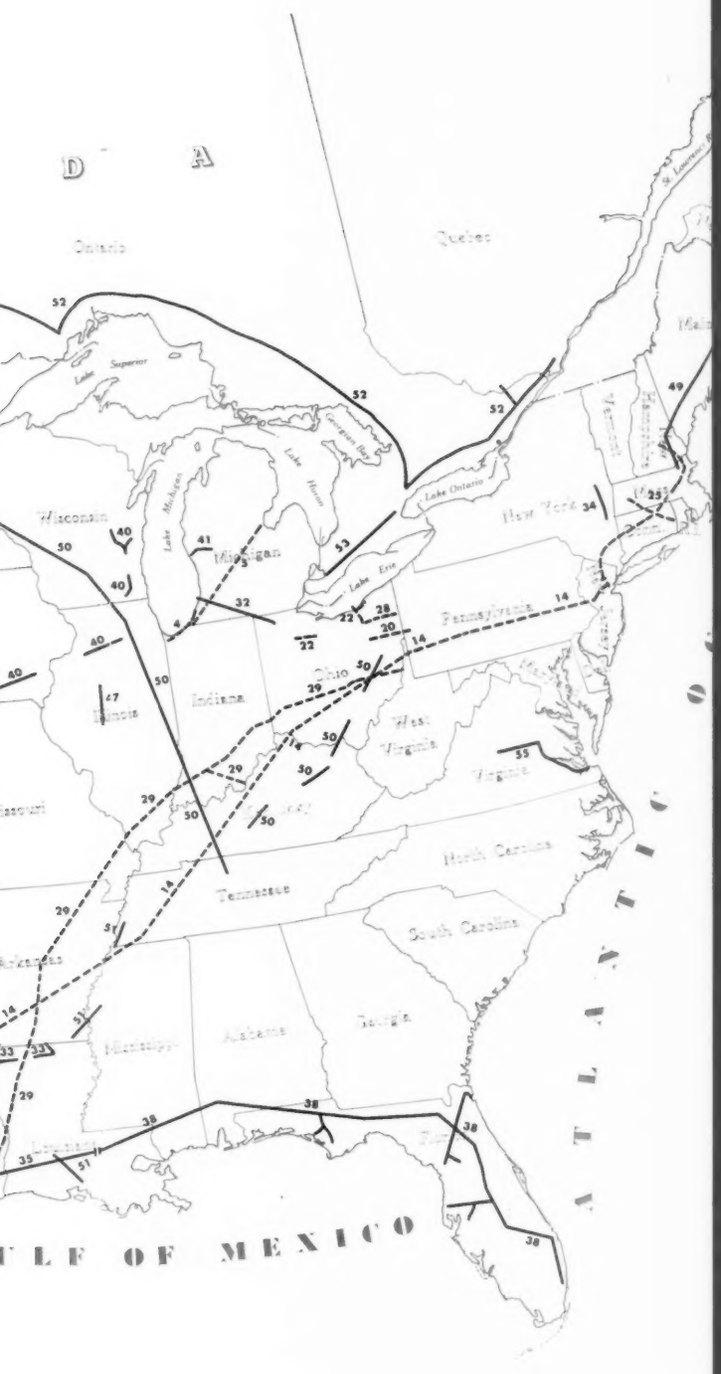
r construction as of October 1, 1955,
Engineer's annual survey

Planned or Proposed

This map shows lines planned, proposed, or approved bu
as reported in The Petroleum Engineer's annual

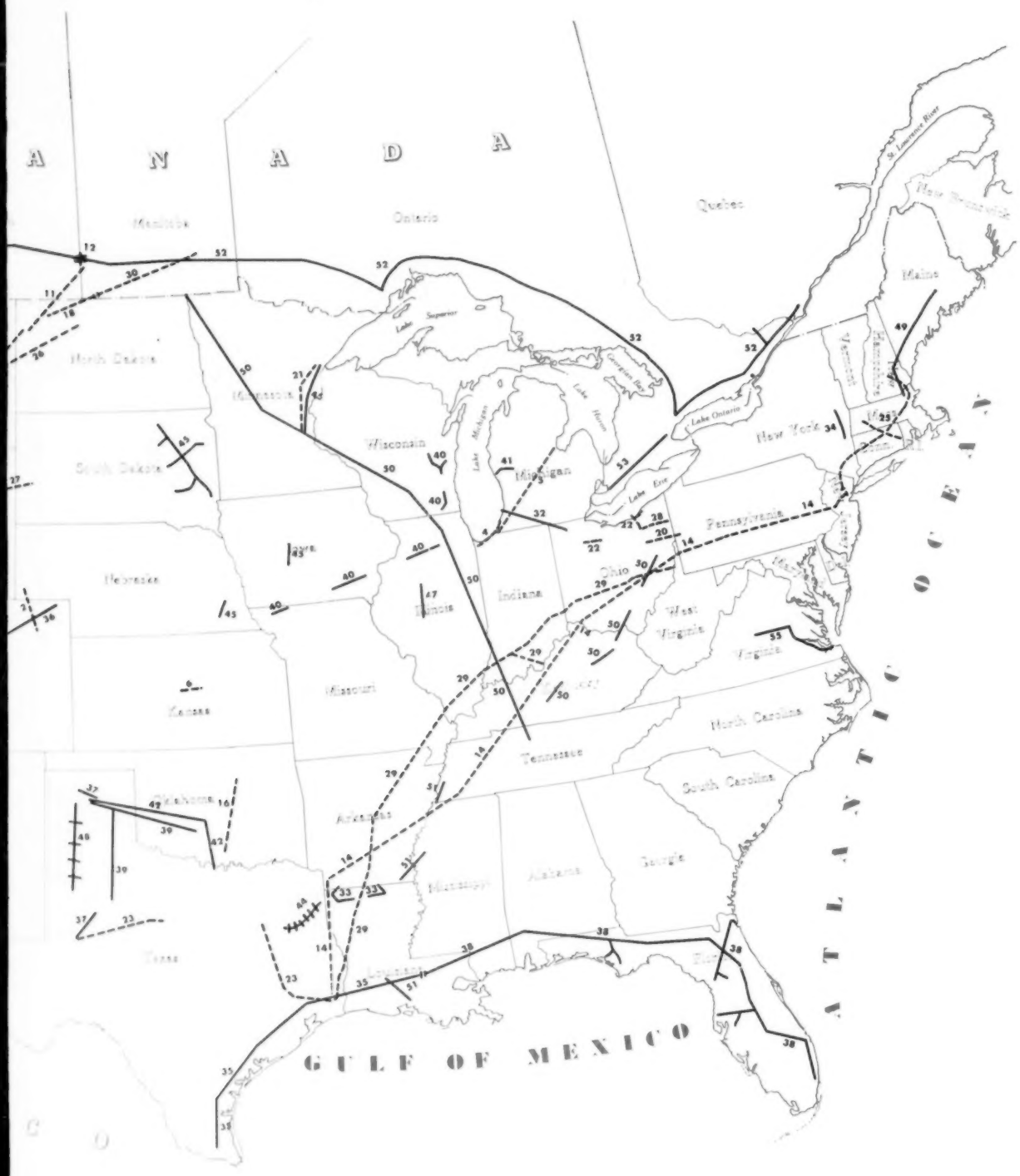
sed Lines

proved but not contracted,
's annual survey



...ed or Proposed Lines

...s planned, proposed, or approved but not contracted,
...d in The Petroleum Engineer's annual survey



Key to Map

CRUDE LINES

1. Ar-Mex Pipeline Company
2. Arapahoe Pipe Line Company
3. Big Horn Pipe Line Company
4. Kaybee Pipe Line Company
5. Michi, Inc.
6. National Cooperative Refinery Assn.
7. Peace River Oil Pipe Line Company, Ltd.
8. Pasotex River Pipe Line Company
9. Powder River Pipe Line Company
10. Salt Lake Pipe Line Company
11. Stanmount Pipe Line Company
12. Trans-Prairie Pipe Lines, Ltd.
13. Union Oil Company of California

PRODUCTS LINES

14. American Pipe Line Company
15. Ar-Mex Pipe Line Company
16. Bell Oil and Gas Company
17. California-Oregon Pipe Line System
18. Deep Rock Gas Company
19. El Paso Natural Gas Company
20. Freedom-Valvoline Oil Company
21. International Pipe Line, Inc.
22. Inland Corporation
23. Magnolia Pipe Line Company
24. Malco Pipe Line Company
25. Mayflower Pipe Line Company
26. Moore-Stoner Company
27. Sioux Oil Company
28. Standard Oil Company (Ohio)
29. Texas Eastern Transmission Corporation
30. Winnipeg & Central Gas Company

GAS LINES

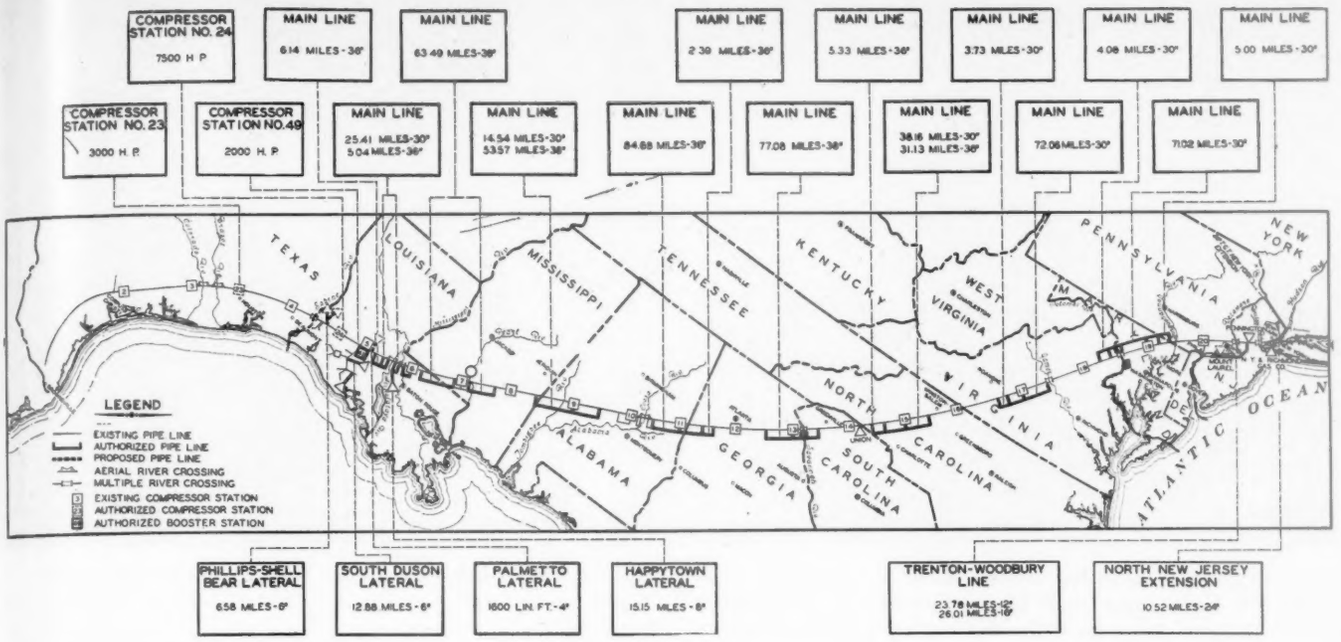
31. Alberta Gas Trunkline
32. American Louisiana Pipe Line Company
33. Arkansas-Louisiana Gas Company
34. Central Hudson Gas & Electric Corp.
35. Coastal Transmission Corporation
36. Colorado Interstate Gas Company
37. El Paso Natural Gas Company
38. Houston Texas Gas and Oil Company
39. Lone Star Gas Company
40. Michigan-Wisconsin Pipe Line Company
41. Michigan Consolidated Gas Company
42. Natural Gas Pipeline Company of America
43. Nevada Canadian Oils, Ltd.
44. North Canadian Oils, Ltd.
45. Northern Natural Gas Company
46. Pacific Gas & Electric Company
47. Panhandle Eastern Pipe Line Company
48. Pioneer Natural Gas Company
49. Pine Tree Natural Gas Company
50. Tennessee Gas Transmission Company
51. Texas Gas Transmission Corporation
52. Trans Canada Pipe Lines, Ltd.
53. Union Gas Company of Canada
54. Utah Natural Gas Company
55. Virginia Natural Gas Company
56. Westcoast Transmission Co., Ltd.

Name of Company	Miles	Size	Location	Date completed	Contractor
Southern Pacific Pipe Lines, Inc., Los Angeles, California	847	8–12–16	El Paso, Texas to Watson, Calif.	UC	Macco-Robertson R. H. Fulton and Company Conyes Construction Co. J. E. Young River Construction Corp Hood Construction Co.
Texaco-Cities Service Pipe Line Company, Tulsa, Oklahoma	45	8	Cushing to West Tulsa, Oklahoma	1955	O. R. Burden
Union Oil Company, Los Angeles, Calif.	18	?	Avila to Guadalupe, California	7–55	Engineers Ltd.

GAS LINES

Alabama-Tennessee Natural Gas Company	25	8–12	Loop lines in Alabama	UC	—
American-Louisiana Pipe Line Company, Detroit, Michigan	1000	30	North Tepetate, Louisiana to Detroit, Michigan	UC	H. C. Price Company Houston Contracting Co. Brown and Root, Inc.
	73	Var.	Gathering and lateral lines	UC	Brown and Root, Inc.
Atalantic Seaboard Corp., Charleston, West Virginia	76	26	Loops in Virginia, West Virginia, and Maryland	UC	Williams Austin Company Pipeline Const. and Drilling Co.
Canadian Western Natural Gas Co., Ltd., Calgary, Alberta	59	2–8	Lines near Lethbridge, Alta.	7–55	Company
Cities Service Gas Company, Oklahoma City, Oklahoma	93	26	Blackwell, Oklahoma to Independence, Kansas	UC	R. H. Fulton and Company
	145	2–20	Gathering system in Barber County, Kansas and Woods County, Okla.	—	Soon to be let
Colorado Interstate Gas Company, Denver, Colorado	373	22	Green River, Wyoming to Denver, Colo.	UC	Houston Contracting Co. R. H. Fulton and Company
	64	4–10	Ft. Morgan to Deertrail, Colorado	7–55	R. H. Fulton and Company
	321	3–20	New lines in Greenwood and Hugoton fields, Kansas; Keyes field, Oklahoma; Panhandle field, Texas	UC	R. H. Fulton and Company
Colorado-Wyoming Gas Co., Denver, Colo.	18	4–16	Lines in Mesa-Thornton area	UC	Vaughn and Taylor
El Paso Natural Gas Company, El Paso, Texas	13.3	*	Lea County, New Mexico	1955	Company Personnel
	32.5	10	Reogan County to Upton County, Tex.	1955	Company personnel
Hope Natural Gas Company, Clarksburg, West Varginia	20	6–16	Lines in Kennedy storage area of West Virginia	1955	—
	23	12	Lines in Logan storage area of West Virginia	1955	—
Kansas-Nebraska Natural Gas Company, Phillipsburg, Kansas	92	3–12	Lines in Colorado, Kansas, and Nebraska	UC	Brodie Construction Co. Creek Construction Co. Sterling Construction Co.
Kentucky-West Virginia Gas Company	32	12	Maytown, Kentucky to Kentucky-Virginia state line	UC	Ranier Construction Co.
Lone Star Gas Company, Dallas, Texas	86	6–18	Lines in Texas and Oklahoma	1955	Company Personnel
Manufacturers Light and Heat Company, Pittsburgh, Pennsylvania	61	4–16	Lines in Ohio, Pennsylvania, and West Virginia	1955	Various
Marine Gathering Company, Houston, Texas	2.9	6–10	Lines in Gulf of Mexico to offshore platforms	1955	Sam Carline, Inc.
Michigan Gas Storage Co., Jackson, Mich.	36	16	Zilwaukee to Mt. Pleasant, Mich.	UC	Bechtel Corporation
Montana-Dakota Utilities Co., Minneapolis, Minn.	121	12	Minot to Williston, North Dakota	UC	Bechtel Corporation
	30	16	Lines in South Dakota	UC	Anderson Brothers
	55	12	Belle Fourche to Rapid City, S. Dakota	1955	Ross-Powers Construction Co.
Montana Power Company, Butte, Montana	76	12	Deer Lodge to Missoula, Montana	—	Ross-Powers Construction Co.
Natural Gas Storage Company of Illinois, Chicago, Illinois	31	36	Herscher to Illinois River, Illinois	UC	Contracting and Material Co.
Natural Gas Pipeline Co. of America, Chicago, Illinois	38	4–16	Vicinity of Rockford, Illinois	UC	Midwestern Contractors
New York State Natural Gas Corp., Pittsburgh, Pennsylvania	23	12–16	Storage pool facilities in Pennsylvania and New York (joint with TGT)	1955	—
	8	6–20	Storage field lines in Pennsylvania (joint with Texas Eastern)	1955	—
	21	20	Loops in Livingston and Wyoming counties, New York	1955	—
Northern Natural Gas Company, Omaha, Nebraska	44	2–16	Permian Basin and Lea County, New Mexico	UC	McVean and Barlow
	27.6	4–6	Hugoton field, Kansas	UC	Reese Bros. Construction Co.
Northern Illinois Gas Company	34	2–12	New lines in Northern Illinois	UC	Midwestern Contractors

Name of Company	Miles	Size	Location	Date completed	Contractor
Ohio Fuel Gas Company, Columbus, Ohio	46	20–24	Loops between Jackson and Crawford, Ohio	1955	—
	28	5–16	Loops in Ohio	1955	—
	11	20	Benton storage area to Crawford station, Ohio	1955	—
Pacific Gas and Electric Company, San Francisco, California	59.5	10–12	Kramer to Trona, California	UC	Engineers Ltd., Alex Robertson
	11.5	10	Ceres to Turlock, California	UC	Alex Robertson
Panhandle Eastern Pipe Line Company, Kansas City, Missouri	295.1	30 26	Loops on main line	12–54	Various
Phillips Petroleum Company, Bartlesville, Oklahoma	119	2–30	Gathering system in Lindsay, Oklahoma, area	UC	Vaughn and Taylor
Pioneer Natural Gas Company, Amarillo, Texas	102.375	4–15	Additions to transmission system	1954–55	—
	513.959	3–8	Additions to irrigation feeder lines (all in Panhandle and South Texas Plains area)	1954–55	—
Southern California Gas Company,	8.7	20–30	Lines near Los Angeles	1955	Alex Robertson, Engineers Ltd. Pacific Pipeline Constr. Co.
Southern Counties Gas Co. of California, Los Angeles, California	31.5	30	Desert Center to Cactus City, California	UC	Engineers Ltd.
Pacific Lighting Gas Supply Company, Los Angeles, California	19	8–10	San Luis Obispo and Paloma-Lake areas	1955	Alex Robertson W. M. Lyles Company
Pacific Northwest Pipe Line Company, Houston, Texas	1067	22–26	Main transmission line between Ignacio, Colorado and Oregon-Washington border	UC	River Construction Corp. R. H. Fulton and Company Associated PL Contractors A. J. Curtis Construction Co. B & M Construction Corp.
	97	10–16	Lateral lines	—	Midwestern Constructors H. B. Zachry Company
	47	2–18	Gathering lines	—	Fulghum Contractors Co.
Southeast Alabama Gas District, Andalusia, Alabama	350	1–10	New system in Alabama serving southeast part of state	UC	Various
Signal Oil and Gas Corp., Los Angeles, California	11	2–8	Gathering system near Tioga, North Dakota	UC	C. P. Bartley
Southern Natural Gas Co., Birmingham, Ala.	46.9	4–30	Lines on system	1955	Company forces
Texas Eastern Transmission Corporation, Shreveport, Louisiana	58	16–20	Jeaquin to Longview, Texas	12–54	Associated Pipe Line Contr.
	29	20	Baytown to Hankamer, Texas	UC	H. B. Zachry Company
	377	30	Beaumont to Kosciusko, Miss.	UC	Houston Contracting Co. H. C. Price Company H. B. Zachry Company Williams Brothers
	28	10	Newton and Orange Counties, Texas	UC	H. B. Zachry Company
Texas Eastern Penn-Jersey Transmission Corp., Shreveport, Louisiana	265	24	Delmont, Pennsylvania to Lambertville, New Jersey	12–54	H. C. Price Company Western Pipe Line Constructors Williams Brothers
Wilcox Trend Gathering System, Inc., Dallas, Texas	16	16	Lavaca County, Texas	UC	Altgelt Construction Co.
Tennessee Gas Transmission Company, Houston, Texas	250	24	Coudersport, Pennsylvania to Greenwich, Connecticut	UC	H. C. Price Company Oklahoma Contracting Co. Bechtel Corporation
	58	20	Kinder to Pecan Island, Louisiana	6–55	Houston Contracting Co.
	56	24–26	Loops on main line in Ohio and Penn.	6–55	H. C. Price Company
	370	30	Agua Dulce, Texas to Kinder, La.	UC	Various
Texas Gas Transmission Corporation, Owensboro, Kentucky	24	16	Eunice to S. Roanoke field, La.	11–54	Houston Contracting Co.
	13.6	20	Loop in Louisiana	6–55	Houston Contracting Co.
	76.8	16	Hardinsburg, Kentucky to Bedford, Indiana	UC	H. C. Price Company
	36.7	10	Bedford to Columbus, Indiana	UC	H. C. Price Company
	77	26	Loops on main line	UC	H. C. Price Company
Transok Pipe Line Co., Tulsa, Oklahoma	140	24	Lindsay to Tulsa, Oklahoma	8–55	Pipeline Service Company
Transcontinental Gas Pipe Line Corp., Houston, Texas	328.8	36	Loops on main line in Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland, and Penn.	—	Various
	232	30			
	94.9	6–24	New laterals and extension on system	—	—
United Gas Pipe Line Company, Shreveport, Louisiana	20.2	20	Iowa field to Cities Service Refinery, Louisiana	1–55	L. E. Farley
	13.9	12	Pescadito to Laredo, Texas	7–55	Fowler
	20.9	12–16	New and replacement lines	1955	Various



Map shows extent of Transco's 1955 expansion, including loops and stations.

36-Inch Pipe Laying Comes of Age

Contractors on 315 miles find problems are few; Transco's $83,000,000 expansion program well underway

Dean Hale
Editor, Oil and Gas Pipelining

Barge drills shot holes for blasting ditch across Tallapoosa River crossing.

CONSTRUCTION EXPERIENCE ON 36-IN. pipe laying passed through its sophomore year in 1955 with six contractors successfully completing the second stage pioneering of big pipe construction on some 315 miles of the super-inch pipe for Transcontinental Gas Pipe Line Corporation on its long distance natural gas system through Louisiana, Mississippi, Georgia, South Carolina, and North Carolina.

In doing so, they proved conclusively that the problems encountered in laying the big diameter pipe were soluble with typical pipeliner ingenuity. And, having overcome the initial obstacles with a variety of solutions and slight alterations in standard practices, they feel the experience gained this year will see further application as the use of 36-in. and even larger diameter pipe becomes more widespread.

First big scale application of 36-in. pipe came in 1954, when Transcontinental laid 47 miles in Mississippi and Alabama. To do the job, the contractor, Associated Pipe Line Contractors, Inc., Houston, selected the "bell hole" method for the two initial sections. Laying the pipe joint-by-joint, with bell holes cut at 40-ft intervals to allow welders room to work, proved to be a fairly good system, requiring a minimum of men and equipment, and eliminating the lowering-in of pipe. It was a reasonable fast method in the good terrain of Mississippi, but much slower in Alabama's more rugged country. With small compact spreads, using yard-coated pipe, construction costs were only slightly higher than for comparable 30-in. construction over the ditch. (*See* THE PETROLEUM ENGINEER, *Page D-51, October, 1954.*)

Equipment Is Big Enough

There was some speculation prior to the start of the 1955 construction season on Transco's 36 and 30-in. looping program as to whether or not present construction equipment would be satisfactory, or be heavy enough to do the job.

The results speak for themselves. Very little special equipment was necessary.

Two ways to lower in. At left, Western Constructors use six sidebooms with slings, "leapfrog" the tractors as pipe goes in the ground. At right, Midwestern Constructors use roller-type cradle equipped with pneumatic tires, all tractor units moving continuously down the line.

Necessity demanded the development of larger coating-and wrapping and cleaning-and-priming machines; sidebooms needed extra counterweights to balance the additional weight of the 36-in. pipe which weighs 155 lb per lineal ft bare, up to 50 per cent greater than comparable 30-in. pipe; changes were made in trenching equipment to cut wider, sloping ditches; and bending machines were modified and new designs built to accommodate the oversized pipe.

Laying Sets Fast Pace

The rapidity at which the pipe has been given its "decent burial" has been remarkable. Transcontinental planners decided on a fall completion date for the 36-in. looping program. The contractors came through with surprising speed, with much of the pipe in the ground, and pressure testing of the line underway.

Some spreads moved at almost mile-a-day clips. In some instances, progress of 7000 ft in one day was reported. Calendar day averages ranged from 3500 ft to nearly 5000 ft per day. On some spreads, almost daily showers and sometimes very heavy rains accounted for lost time days that cut into the daily footage averages.

Over-Ditch Vs. Bell-Hole

Weather was a big factor in the decision of several contractors to adopt the technique of working on the bank rather than the bell-hole method. Long range forecasts foretold of heavy rains during the summer months in the six-state area of the south where the line is being laid, in contrast to the unusually dry summer of 1954.

If the bell-hole method had been used, it is doubtful that construction would be more than half complete by this time. Bell-holes full of water or mud are uncomfortable places to work, and pipe line welders, like most people, are reluctant to continue working under such conditions over long periods of time.

Only five miles of the 315 miles of 36-in. laid this year were constructed by the bell-hole method. When specifications were drawn for the 1955 looping program, Transco left the choice of construction methods up to the individual contractors. The result was that various methods of ditching, welding, coating, and lowering-in are being used by the six contractors.

Techniques Used . . .

Ditching. In most cases, standard ditching machines have been used. Minimum ditch required for the 36-in. is 66-in. deep and 48-in. wide. Most of the ditch actually cut has a bottom width of from 52 to 56-in. width and up to 96-in. at the top.

The wide top is the result of using slopers with the conventional bucket wheels. Sloping proved advantageous in cutting down on ditch cave-ins resulting from the extra-heavy pressure

Pipe gang, at left, on Associated spread, found the "skid rack" mounted on front of gang's sideboom a real time saver. Welded of from left-over small-diameter pipe pieces, the rack keeps that "extra skid" close by.

Below, right, Midwestern pipe gang works as compact unit on yard coated pipe.

Two ways to add to the counterweights. At left, a U-shaped weight fabricated from large-diameter pipe and filled with concrete, is wrapped around regular weights. At right, a "box" made from sheet steel, welded to top of standard weights, and filled with concrete does the job.

exerted on the bank by the greater amount of heavy equipment working with the pipe, and from the added weight of the heavier 36-in. pipe.

In most cases, contractors used two ditchers simultaneously in order to get the required progress, the machines "leapfrogging" each other as they completed their sections.

On one spread, the contractor employed a unique three-unit equipment operation. A ripper equipped tractor was used to break the soil down the ditch line, followed by a pilot ditcher cutting a narrow ditch and depositing its soil at regular conveyor distance. This was followed by a larger-sized ditcher to cut the final ditch. The latter machine was equipped with track "wheelbase" extended two feet in order to straddle the pilot ditch and an extended conveyor for depositing soil further out from the ditch center line.

In areas where rock was encountered, the same contractor used a small, 'dozer-equipped "baby" crawler tractor inside the ditch to smooth the bottom.

Where blasting was necessary, backhoes or clamshells were used to finish the ditch on most spreads.

Bending. No trouble was encountered in bending the 36-in. pipe. Both cable and hydraulically operated bending machines were used, including a new type vertical hydraulic bender that received its maiden workout on the 36-in. pipe.

For handling yard-coated pipe, one innovation proved very useful — small airplane type pneumatic tires were strategically placed in the forming shoes. The tires served two purposes — to enable moving the pipe in and out of the bender with ease, and to prevent damage to the coating.

Welding. On practically all of the spreads, there was little variation in the welding crew organization. Pipe gangs varied from three to five stringer bead welders, with hot pass welders also ranging from three to five.

The bigger diameter pipe and slightly heavier wall thickness (.406-in.) slowed progress on the firing line, compared to 30-in. pipe welding. In some cases, pipe gangs got so far ahead of the firing line, that the pipe gang welders shut down and worked back down the line to help firing line crews keep up.

On one spread, a new type welding machine was given extensive testing and use, and proved highly satisfactory.

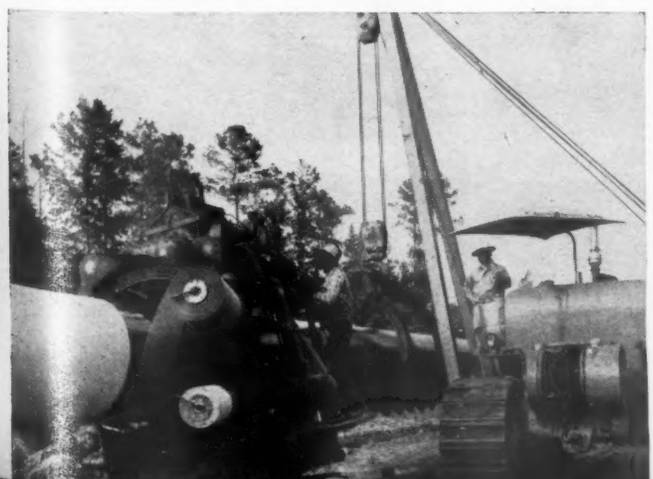
The big pipe was skidded to a height that would give the welders as much working room as possible. Even then, in some cases, it was necessary to use small stepladders to reach the top of the pipe.

Coating and Wrapping. Various reasons entered into the decisions by the contractors to use either yard-coated pipe or to clean-and-prime and coat-and-wrap the pipe on the ditch bank. Two contractors selected yard-coated pipe, one citing the possibility of rain, the other naming lower cost as reasons for their decisions.

By using yard-coated pipe, a saving in equipment — up to four tractors — is possible. The method also speeds up work and a savings in time means money to the contractor. It also eliminated considerable extra handling of the pipe, as in coating over the ditch where the pipe is picked up for cleaning and priming, placed back on skids, and then picked up again for coating and wrapping, and replaced on the skids. With yard-coated pipe, no handling is needed after line-up until lowering-in.

As an extra precaution in preventing damage to the yard-coated pipe, one contractor placed pillows — bags containing sawdust, meal or sand — between the top skid and the bottom of the pipe as a "cushion." This method

Coating and wrapping machine was specially developed for the 36-in. pipe. Pipe was wrapped with glass fiber and kraft paper.



Cleaning and priming the 36-in. pipe over the ditch. Both asphalt primer and asphalt enamel were used.

worked very well, reducing patching of the coating to a minimum.

The contractors who decided to clean and coat the pipe in a conventional over-the-ditch manner found both new and modified standard cleaning-and-priming and coating-and-wrapping machines available for their use. One firm developed special new equipment for the 36-in. pipe.

In areas where long runs without interruption were possible — and these were not uncommon — the over the ditch method proved quite speedy, and on some spreads, the dope gangs had to shut down early at times as they closed in on the firing line.

Over-the-ditch coating of the pipe has another advantage, its proponents, point out. The extra handling of the pipe to and from the stationary coating yard is eliminated.

All of the pipe used by Transco is being coated with asphalt base primer and enamel, with a glass fiber wrap and an exterior wrap of kraft paper.

Lowering-in. Equipment requirements for lowering-in of the pipe varied from spread to spread, depending on the terrain and methods used by the individual contractors.

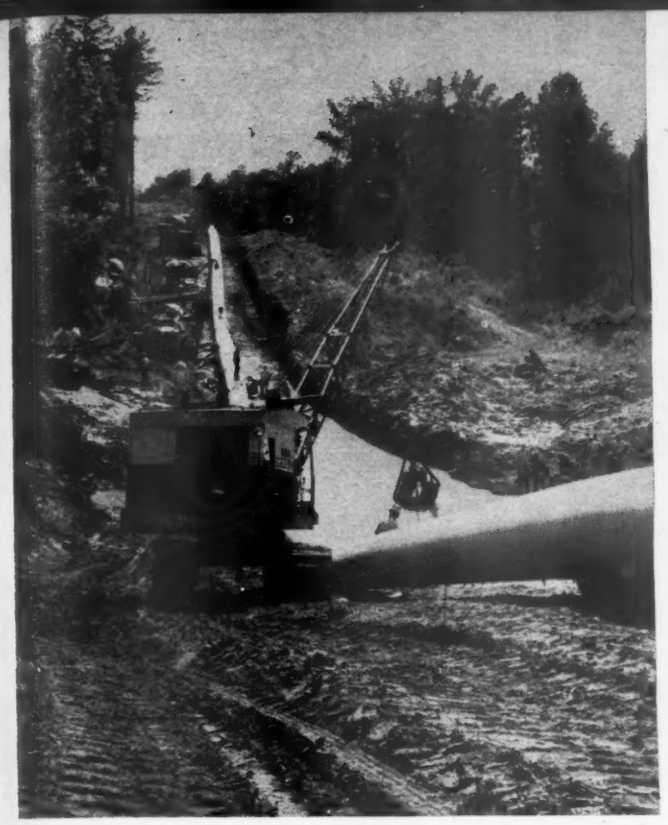
Generally, from five to eight sideboom-equipped crawler tractors were found in use, all of them the largest machines available. Compared to 30-in. construction, this is from one to three more units for a similar operation. (One contractor, laying both 30 and 36-in. on the same loop section, switched from five tractors for just the lowering-in operation to three tractors for a combination coating-and-wrapping and lowering-in-after-coating operation.)

To gain additional counterweights for the sidebooms, the ingenious pipeliners came through with several innovations, such as U-shaped weights made of short pieces of pipe and concrete-filled that fitted over the standard counterweights. In some cases, they merely constructed large rectangular boxes of sheet metal, filled with concrete, and tied by wire rope or welded to the top of the standard weights.

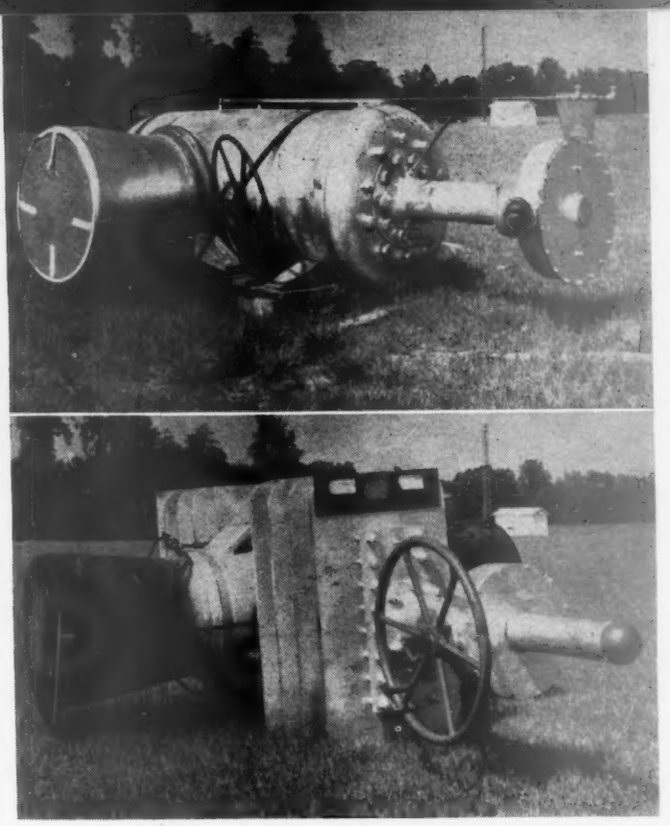
Ditching. Above, left, pilot ditcher on Houston Contracting spread cuts a narrow guide trench. It is followed (right) by a larger ditcher equipped with extended conveyor and widened tracks to cut ditch to final size. In areas where ground is rocky or hard or both, a ripper-equipped tractor precedes the pilot ditcher.

Sloped ditch helps prevent cave-ins from frequent rains, extra heavy pressure exerted on ditch bank by equipment and heavy pipe (155 lb per lineal ft bare). Progress is slowed by cutting sloped ditch, so two machines are used, which "leap-frog" each other.

"Baby" tractor is hardly 4-ft wide, equipped with midget dozer blade, and used by Houston Contracting to smooth ditch bottom in rocky areas.



Clamshell cleans out stream crossing at bottom of deep ravine as lowering-in crew moves up to location in background.



Valves. At top, a full opening 30-in., with 36-in. to 30-in. reducing fittings. At bottom, new type 24-in. valve, with 30-in. to 24-in. reducing fittings.

Hydrostatic Testing. All sections of the loop line, both 36 and 30-in., are being hydrostatically tested. All water injected into the line for this test is being filtered to prevent accumulations of silt and other material in low points on the line, on the walls of the pipe, and in gate valves. After initial fill, the line is pressurized to 1040 psi. Readings are taken at specified intervals for possible drops indicating leaks and the section being tested is patrolled to spot any obvious leaks.

One contractor specializing in hydrostatic testing used two stage centrifugal pumps driven by 325-hp engines to pick up the water and force it thru the filters and into the line until a head of approximately 130 psi is reached. At this point, a triple pump driven by 325-hp engines through a torque converter is cut into the line and is used to continue filling operations and build up pressure to the 1040 psi level. The torque converter driven triplex pump is used because it imparts a minimum amount of vibration to the line.

Valves. For both main line gates, at tie-ins with the original 30-in. line, and on the station manifolds, the valves installed in conjunction with the 36-in. pipe can be considered "big". Included in the valve equipment are both widely-used standard gate valves and some of the newest developments in valve equipment.

Internal Pipe Coating. More than 200 miles of the 36 and 30-in. used in the 1955 Transco looping program has been internally coated with an epoxy resin. Transco engineers point out that the use of the internally coated pipe is strictly experimental, and is being tried chiefly because the internal coating process eliminates mill-scale and dirt that fouls up valves, compressor cylinder walls, and creates other problems and damage.

There is also a good possibility that the internally coated pipe will increase flow efficiency. Tests underway by other companies have shown that flow efficiency is boosted by the smooth walls. Transco plans to study the effects of the internal coating after the line is placed in operation.

Damage to the internal coating at the pipe ends from welding is almost negligible. The coating is "burned" about ½-in. on either side of the weld, with a slightly charred result. But the tough epoxy resin, well cured, so far hasn't shown any signs of peeling or breaking its bond.

Economics. The cost of installing 36-in. pipe, both for materials and for

Hydrostatic testing equipment. At left is triplex pump unit, driven by 325-hp engine through torque converter, is used to build pressure to 1040 psi. At right, centrifugal unit picks up water from stream, forces it through filter in foreground, and is used to fill line up to pressure of 130 psi. All water used in line was filtered.

Bending. At left is new type vertical hydraulic bender, used for first time on Transco job.

Pneumatic tires in this vertical cable bender prevented damage to yard-coated pipe.

actual construction, comes fairly high. But in relation to the increase in throughput capacity gained by the additional 6-in. in diameter, Transco feels that 36-in. pipe is justified.

The company wanted to increase its daily deliverability capacity by 130,000,000 cu ft, and the most economically feasible means determined by long study was the use of the 36-in.

Contractors

Seven firms shared in the original 534 miles of 36 and 30-in. work. They include:

O. R. Burden Construction Corporation, Tulsa, Oklahoma, 25.39 miles of 30-in. and 5.07 miles of 36-in. in Louisiana.

Associated Pipe Line Contractors, Inc., Houston, Texas, 63.49 miles of 36-in. in Louisiana and Mississippi and 71.02 miles of 30-in. in Virginia and Maryland.

Midwestern Constructors, Inc., Tulsa, Oklahoma, 53.57 miles of 36-in. and 14.54 miles of 30-in. in Mississippi and Alabama.

Houston Contracting Company — H. C. Price Company (joint venture) Houston, Texas, 84.68 miles of 36-in. Alabama and Georgia.

Western Constructors, Austin, Texas, 77.08 miles of 36-in. in Georgia and South Carolina.

Panama-Williams Corporation, Houston, Texas, 31.13 miles of 36-in. and 36.16 miles of 30-in. in North Carolina.

Williams Brothers Company, Tulsa, Oklahoma, 72.06 miles of 30-in. in Virginia.

In addition to the main line loop projects, Transco received temporary authorization from the FPC in July to lay an additional 13.86 miles of 36-in. and 12.01 miles of 30-in. Most of this work was in short sections adjacent to loops under construction.

Contracts on this work include 2.39 miles of 36-in. in Georgia by Houston Contracting Company and H. C. Price Company, and 3.73 miles of 30-in. in Virginia by Williams Brothers.

Remaining are 6.14 miles of 36-in. in Louisiana, 5.33 miles of 36-in. in North Carolina, 4.08 miles of 30-in. in Virginia, and 5 miles of 30-in. in Maryland and Pennsylvania.

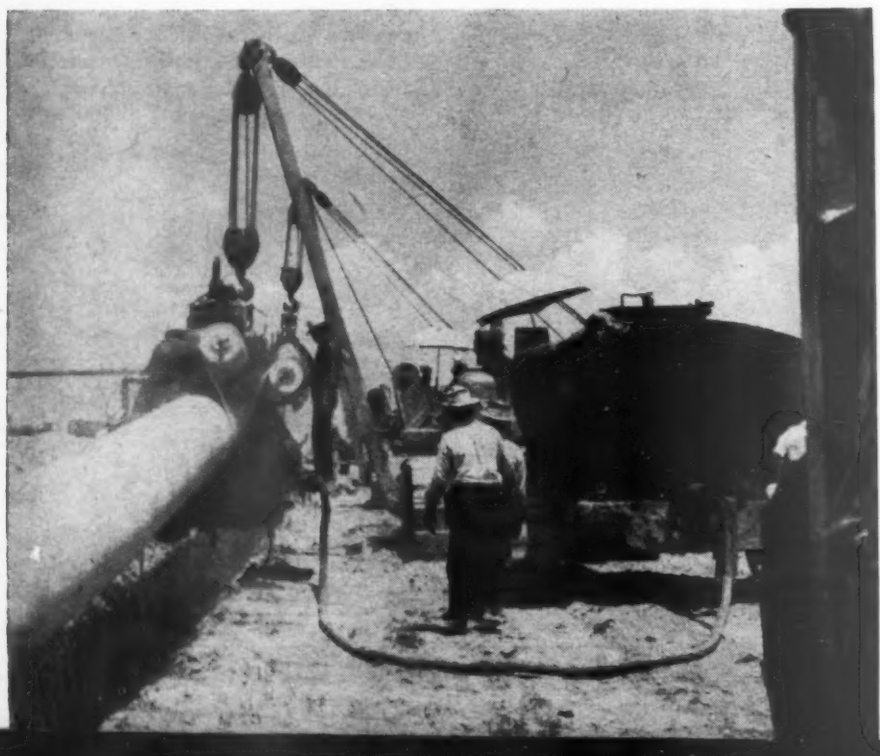
Big Expansion Program

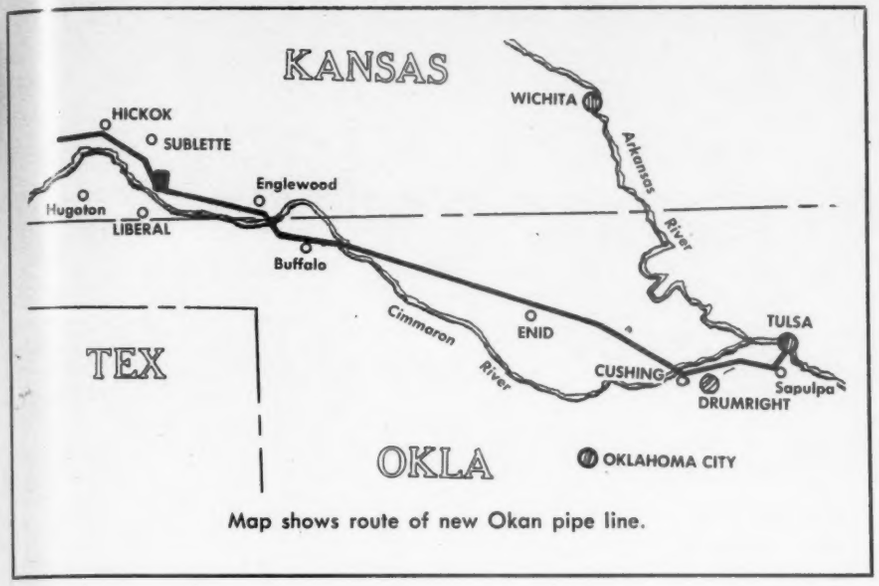
Transcontinental Gas Pipe Line's extensive expansion program, which will cost about $83,000,000, is designed to increase its system delivery capacity to 695,000,000 cu ft daily.

In addition to the approximately 329 total miles of 36-in. and 232 miles of 30-in. loop, Transco will add 49.42 miles of 12 and 16-in. line between Trenton and Woodbury, New Jersey; a 10.48 mile, 24-in. line extension in northern New Jersey; and 20.52 miles of 8-in. in two laterals in Louisiana. Plans also call for 19.46 miles of 6-in. in two laterals in Louisiana, and a short 4-in. lateral and purchase meter station.

Three new stations are also being added to the system. Near Houston, a new station that will mark the first application of an engine-driven centrifugal compressor is being installed (SEE THE PETROLEUM ENGINEER, *Page D-77, May, 1955*). A second station in Louisiana will have three 2500-hp angle reciprocating units. A third station of 2000-hp is being installed as a booster station in South Central Louisiana. * * *

On 30-in. pipe, Panama-Williams Corporation crew lowers in pipe after coating and wrapping, using three sideboom tractors. Similar 36-in. operations would require three tractors for C&W, five more on lowering-in.





Map shows route of new Okan pipe line.

Construction Report

New Okan Pipe Line System To Carry LPG, Natural Gasoline

353-Mile Hugoton to Tulsa system now delivering products for refinery blending

OKAN Pipeline Company, affiliate of Warren Petroleum Corporation, recently completed a 6 and 4-in., 353-mile pipe line from the Hugoton gas field to Tulsa, Oklahoma, for transportation of natural gasoline products. The line originates in the southwestern Kansas portion of the vast Hugoton gas producing area and has been designed for an initial capacity of 10,000 bbl a day, ultimately to be increased to 20,000 bbl. The system is operating as a common carrier and for the present only natural gasoline is being shipped, which is being taken by D-X Sunray Oil Company's West Tulsa refinery for blending purposes. As markets are developed, other products, including LPG, will be moved through the line.

Four natural gasoline plants are supplying the system. These are the Stano plant of Stanolind Oil and Gas Company, Liberal plant of Panhandle Eastern Pipe Line Company, Sublette plant of Northern Natural Gas Company, and Hugoton Production Company's plant near Ulysses.

For the current capacity of 10,000 bbl a day only one pumping station is required. Located at Liberal, Kansas, it is an outdoor-type station consisting of one 800-hp gas engine driving a 9-stage centrifugal pump through a 3.94 to 1 speed increaser. A duplicate unit has been installed to serve as a standby and to share the increased load when maximum line capacity will be attained during winter months. Later, when ultimate line capacity is desirable, additional pumping stations will be needed.

The line is designed to operate with local automatic control at the station and utilizes latest developments in telemetering and remote supervisory control techniques.

EXCLUSIVE

Natural gasoline plants supplying the line have sufficient storage tanks for five days' production, and at Okan's Liberal station two 20,000-bbl pressure storage tanks have been erected. The tanks will be used for product segregation and batch accumulation, and products will be measured into the system through positive displacement meters.

Construction Procedures

Construction work was divided into three jobs. R. H. Fulton and Company of Lubbock, Texas, had Job 1, the 6-in., 137-mile section from Tulsa to Goltry, Oklahoma, northwest of Enid. This section passes near Drumright, Cushing, and Enid. The 150-mile, 6-in. section from Goltry to Liberal, Kansas (Job 2) was constructed by Vaughn and Taylor Construction Company of Odessa, Texas, as was Job 3, consisting of 66 miles of 4 and 6-in. laterals extending from the main line to the four gasoline plants.

Main line pipe was coated with hot enamel to a thickness of 4/32 in. and wrapped with 8-lb felt. River crossings, of which there were three and all of the Cimarron, were given added protection. The crossings were laid of seamless pipe having wall thickness of 0.375-in., were mill coated with 4/32-in. enamel and wrapped with 15-lb felt; however, to this was added a flood coating of enamel and a rock shield wrap in the field.

Welds at river crossings, highways, and railroad, were X-rayed 100 per cent. Elsewhere spot checks were made. Block valves were installed at about 30-mile intervals. Insulating flanges were placed at 50-mile intervals in order that cathodic protection may be provided at a later date.

A number of subcontractors participated in the project. Percy Jones Trucking Company of Oklahoma City strung pipe for Vaughn and Taylor. Coating and wrapping from Goltry west was sublet to Briggs Engineering and Contracting Company, Midland, Texas. Continental Construction Company, Big Spring, Texas, installed road crossings on Vaughn and Taylor's sections. Mill coating of pipe for river crossings was by Bennett-Rogers Pipe Coating Company, Kansas City. Elder and McNulty, Tulsa, made the X-ray inspection of welds.

The Okan Pipe Line organization consists of Ernest A. Slade, president; Charles W. Miller, vice president and general superintendent; Gil V. Rohleder, chief engineer, who are also directors of the corporation; D. M. Mattocks, secretary; A. J. Murphy, treasurer; A. B. Scurlock, civil engineer; G. D. Griffee, assistant engineer; T. M. Moore, material supervisor; L. A. Jackson and A. J. Wisdom, right-of-way.

Motor-driven centrifugal station at Ponca City pumps in two directions—to Wichita and Oklahoma City.

P 615.05

THE CHEROKEE STORY

Take five pipe lines or segments thereof, tie together, and convert parts of them to products service . . . that's the successful formula used to fashion together the amazing 2262-mile Cherokee Pipe Line system

Frank H. Love
Editor-in-Chief

THE story of Cherokee Pipe Line is the story of how five pipe line systems, or parts thereof, were fashioned into a single network for combined transportation of crude oil and refined products. It is an interesting and instructive story.

Backbone of this 2262-mile system are the Oklahoma lines of Interstate Pipe Line and all those of Ajax, the latter extending from Oklahoma into Illinois. Purchased additionally were certain pipe line segments needed to complete the plan, the whole being tied together by new pipe laid at strategic points.

Because parts of the Cherokee system are used for products movement, and all of the combined pipe lines formerly were in crude oil service, a considerable cleaning problem was involved. There was also the need to install entirely new pumping equipment on this part of the system. For those lines that would continue to transport crude the difficulties were not so great.

The manner in which the several problems were met and solved is particularly noteworthy because most of the lines had been in use for many years, one for 40 years, another 31 years, still another 25.

Formation of Cherokee was the outgrowth principally of economic factors involving Interstate and Ajax. Development of Canadian oil production during the last few years had eliminated the major affiliated movement through the Interstate-Ajax system. Further loss of business was the result of the general condition of oversupply in the industry. Long-term commitments, mainstay of the pipe line business, thus were lacking. Result was organization of Cherokee to deliver both refined products and crude and to a larger group of purchasers.

The new company is a combined operation of Cities Service Pipe Line

Ponca City station receives products from five remote booster pump locations. Each stream has a bank of three positive displacement meters, two for measuring the stream, the third serving as a standby and for proving the other two.

Company and Continental Pipe Line Company. Continental operates the products division and Cities Service the crude oil division. All employees are from Cities Service and Continental staffs, working under contract for Cherokee. The latter, in effect, has no employees of its own other than executive officers.

Cherokee Pipe Line, over its 1614 miles of crude oil lines, is now delivering crude to Oklahoma City, Cushing, and Drumright, Oklahoma, and Wood River, Illinois. Products, with 648 miles of line, find outlets at Wichita, Kansas, Mount Vernon, Missouri, Wood River, and Oklahoma City.

Crude Oil System

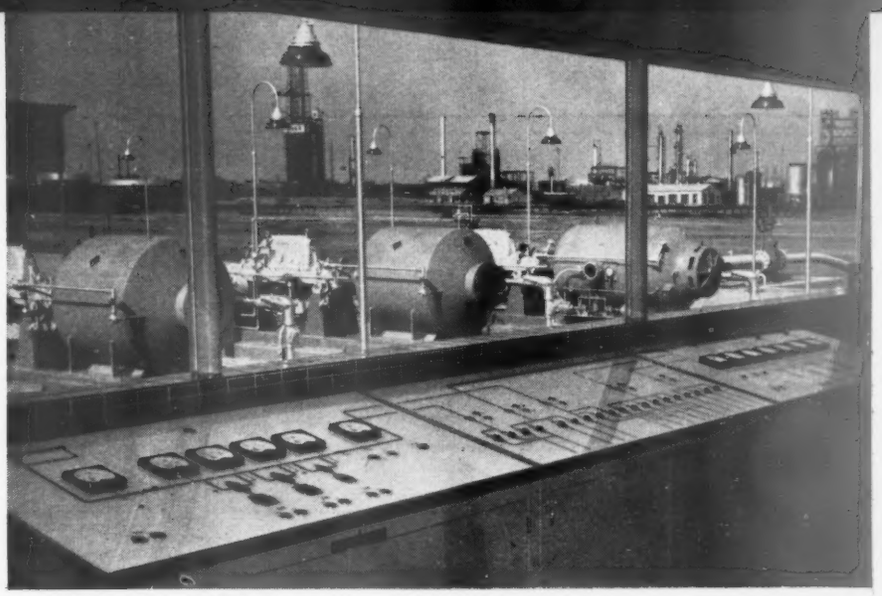
Although the crude oil portion of the system involves considerably more mileage, it was worked into the over-all system with far greater ease than were the lines used for product movement. The reason is obvious. Lines used for product shipment required maximum cleaning to avoid contamination and new pumping equipment had to be installed for this particular service. On the other hand, the lines used for crude oil transportation had been in operation until the time they were purchased by Cherokee, so required no major reconditioning. Pumping equipment, although old, for the most part was found serviceable after minimum repairs and adequate for the demands upon it.

Cherokee's crude transportation system from Glenpool to Wood River includes one of the former Ajax's 10-in. lines between those points, the former Interstate system in south and central Oklahoma composed of 6, 8, 10, and 12-in. pipe lines, plus 24 miles of new 8-in. laid to enable better segregation of the crudes. Addition of the last makes it possible to bring the two types of crude into Glenpool station through separate lines. As a part of the segregation program three 80,000-bbl storage tanks were erected, one at Tussy and two at Maysville.

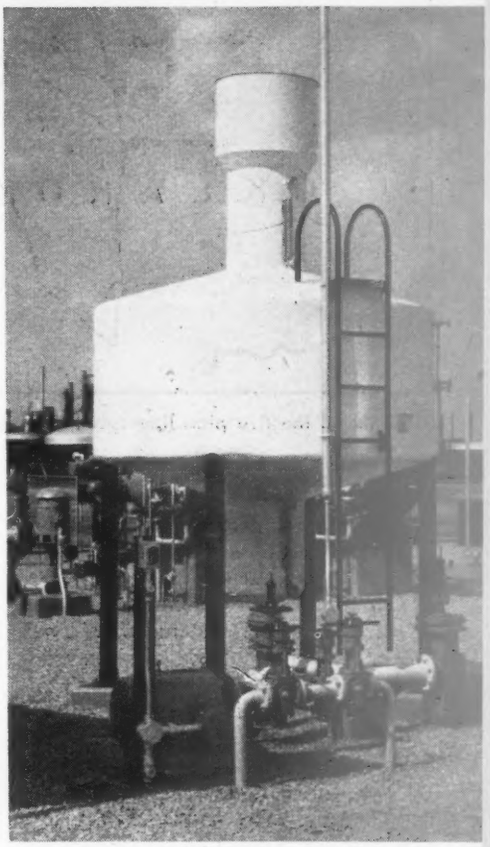
Also in the picture is a complete gathering system in the Lindsay area acquired from Cities Service Pipe Line Company. Between Cushing and Glenpool are two 8-in. lines, a part of the former Interstate system.

Capacity of the system is 35,000 bbl a day from Glenpool to Wood River, but in south-central Oklahoma it is 75,000 bbl, heavy deliveries being dropped off at Oklahoma City, Drumright, and Cushing.

Stations on the Ajax and Interstate systems consist of diesel-driven pumps. Despite the many years of service, most of this equipment is being used by Cherokee. Exceptions are at Cromwell and Francis stations where the

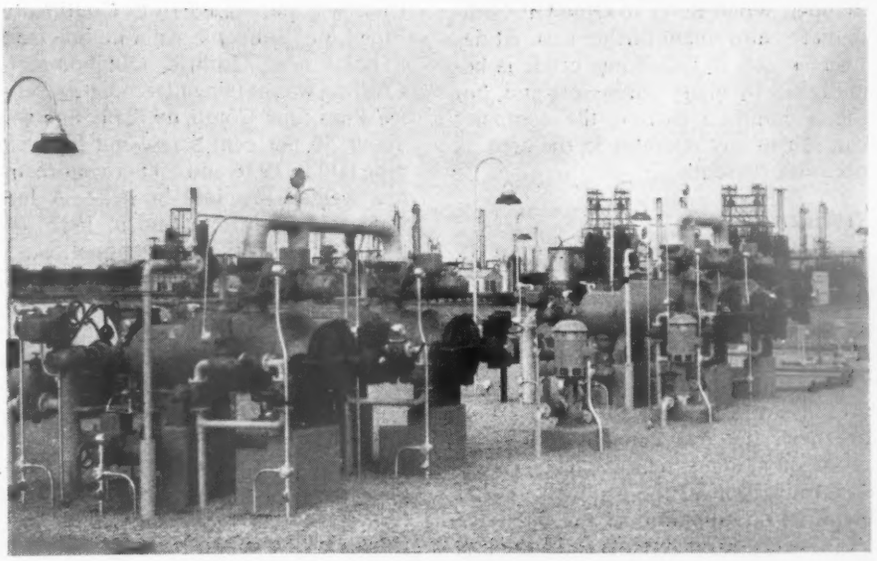


Console desk contains schematic plan of all station piping and equipment; lights to indicate valve position; warning lights; push buttons for starting and stopping pumps, horn reset, alarm tests, and emergency shutdown.



In addition to proving meters by means of master meters, this prover tank is also used for calibration purposes.

Incoming product streams before being metered pass through self-cleaning type strainers having 200-mesh screens.



Map shows the five pipe line systems, or parts thereof, that were tied together to form Cherokee.

diesels have been replaced by motors to drive the existing reciprocating pumps. At all other stations there are three 500-hp diesels.

Communication facilities on the south end of the system, which was Interstate, consist of combination radio and physical circuits. Between Glenpool and Wood River wire line is used exclusively.

As has been indicated, Cherokee has its own gathering system but also receives crude on its main line from several pipe line companies. Deliveries are made at Wood River to Ohio Oil Company for movement farther east. At delivery points in Oklahoma crude is being taken by many purchasers and, being a common carrier, the company can sell to any operator in the area as occasion presents.

Products System

The products system consists of 58 miles of 6-in., 192 miles of 8-in., and 398 miles of 10-in. line, with pumping stations at Ponca City and Glenpool, Oklahoma, and Mount Vernon, Missouri. Of this total only 8 miles of 6-in., 20 miles of 8-in., and 3 miles of 10-in. are new, the rest being parts of the crude oil systems mentioned.

Formulation of the products system required coordination of the purchase of these crude oil systems from the five companies and the visualization of how they could be interconnected to fit the needs of product shipment and form an economically stable system.

The 6-in. and 8-in. pipe lines extending from central Kansas, to a point near Tonkawa, Oklahoma, were purchased by Cherokee from Shell Pipe Line Company. This was a lap-weld screw line originally laid in 1924 and reconditioned in 1947. A seamless welded 8-in. crude line laid in 1931 and reconditioned in 1943, extending from a point near Ponca City to Oklahoma City, was purchased from Continental Pipe Line Company. An 8-in. line from a point near Guthrie, Oklahoma, to Cushing was obtained from Cities Service Pipe Line Company. This line was about 50 per cent screw-end lap-weld pipe laid in 1936 and 50 per cent seamless welded line laid in 1952. A lap-weld screw 8-in. line laid in 1915, between Drumright and Glenpool, was a portion of the Oklahoma system of Interstate, and a lap-weld, weld-joint 10-in. line laid in 1930, extending from Glenpool to Wood River was one of two lines purchased from Ajax.

By constructing 8 miles of 6-in., 20 miles of 8-in., and 3 miles of 10-in., as indicated on the accompanying map, these five systems were interconnected to form a combination 6-in. and 8-in. products line between Ponca City and Wichita, an 8-in. line from Ponca City to Oklahoma City, and a combination 8-in. and 10-in. line from Ponca City to Wood River.

Conversion to Products

The first step in converting these lines to products service was construction of small sections of line to tie the systems together. Because portions of the system formerly were parts of multiple crude oil systems, all crossovers, station tie-ins, and similar installations were cut and replaced with new sections of pipe so that the entire system was completely separated from all other lines, leaving no tees or connections of any kind that would act as dead space and possibly result in product contamination.

After this work was completed, the combination 6-in. and 8-in. line from Ponca City to Wichita was the first section to be cleaned. The line fill for this section was about 16,500 bbl and an ideal situation existed as there was a crude oil line that passed within 100 ft of the terminus of the line at Wichita into which the crude oil could be displaced.

After making laboratory tests to determine the cleaning capabilities of various products, it was decided to use No. 1 fuel oil for this particular section. The laboratory tests indicated that

The complete Cherokee system. Dotted lines show where new pipe was laid to connect the several parts.

it would require 8000 to 10,000 bbl to clean the section adequately. As this was the first section to be cleaned, it was decided to play safe and use 15,000 bbl of fuel oil and check the results carefully to verify laboratory findings. This would give basic information for cleaning other sections.

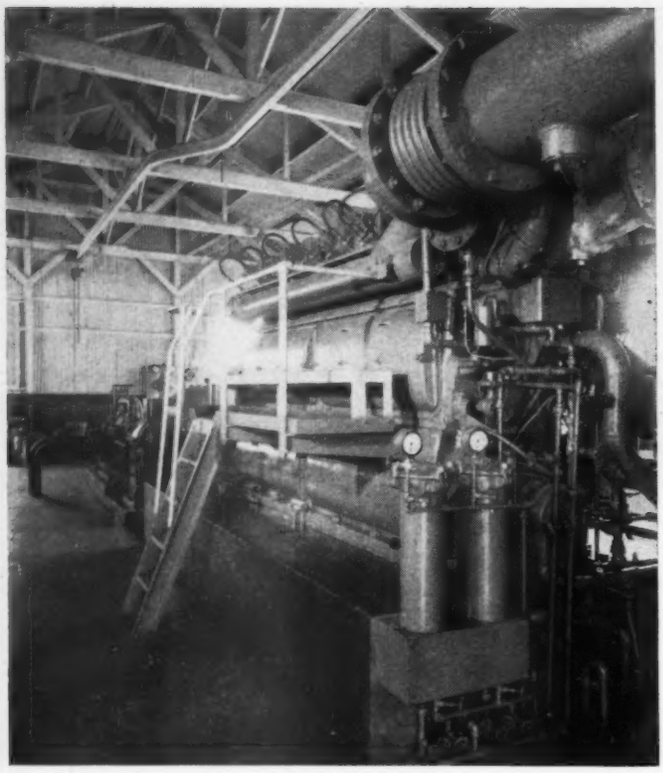
Procedure was to pump the No. 1 fuel oil into the system at Ponca City, displacing crude through a temporary connection into the crude oil line at Wichita. The fuel oil was also pumped into the crude line and returned to the refinery for reprocessing. Upon arrival of the head of the fuel oil wash at Wichita hourly samples were taken. Laboratory tests were verified in that when 8000 bbl of fuel oil had been pumped into the system the line was cleaned to where the product would pass color specifications. The remainder of the 15,000 bbl of fuel oil was pumped through the line, however, after which a good clean product was obtained.

At this point in the cleaning operation a complete laboratory analysis was made of the JP-4 (jet fuel), which was the product following the line wash. It was found that the JP-4 had picked up sulfur from the line to a degree that it would not pass specifications. Considering that 15 knife and brush type scrapers had been run through the line with the wash oil, and also that the last 5 or 6 scrapers picked up but little wax or other contamination from the line, it was not felt that additional scrapers would solve the problem. It was decided, therefore, to let the JP-4 remain in the line for a few days, take samples, and observe the sulfur content. Sulfur content of these samples was erratic and additional JP-4 was pumped into the line, displacing the contaminated product into the crude line for return to the refinery for reprocessing. This second line fill also showed sulfur contamination. So, again the JP-4 was allowed to remain in the line, and samples taken during the next few days indicated a marked increase in sulfur content. Obviously, the JP-4 was leaching sulfur from the walls of the pipe, so it was allowed to remain in the line and the sulfur content checked regularly until there was no further increase in sulfur content. Again the line was displaced and after this displacement the product met specifications.

From the experience obtained in cleaning this section it was concluded that sulfur had been imbedded in small pits and deposited behind mill scale by the high sulfur content of the West Kansas crude previously moved through the line. Attempts to remove the sulfur by continuous running of scrapers would have taken an enormous quantity of line wash. It was concluded that the leaching process utilized was the most satisfactory method for removing the imbedded sulfur. This conclusion resulted from tests of the mill scale that arrived with the last scrapers run with the line wash. The concentration of sulfur in this mill scale, along with the fact that laboratory tests of samples definitely indicated the leaching of sulfur by the JP-4, indicated that it probably would be necessary to remove all mill scale to eliminate the sulfur entirely if scrapers alone were used.

During the initial washing of the first section of line a flow pressure test of 250 psi in excess of maximum operating pressure was placed on the line and no leaks resulted.

Next the section from Ponca City to Glenpool to Wood River was cleaned



Practically all pumping equipment on the crude oil portion of the system was serviceable with minimum renovation. At left is diesel engine driving centrifugal pump at Oklahoma City station. Above is exterior of Francis station near Seminole.

all in one movement. Again from results of laboratory tests it was determined that 50,000 bbl of No. 2 fuel oil would be used for line wash. One of the products to be delivered at Wood River was No. 2 fuel oil, so a batch of 120,000 bbl was started through the line. Twenty-three knife and brush type scrapers were run through the 8-in. line from Ponca City to Glenpool. Between Glenpool and Wood River 10-in. scrapers were run, 32 being used. Due to a plugged line at one location, it was necessary to remove several of the scrapers and they were not returned to the stream. After receiving approximately 50,000 bbl of the No. 2 fuel oil at Wood River, it was determined by test that the product would meet specifications and was diverted to terminal tankage.

The section from Cimarron Junction to Oklahoma City was cleaned as a separate segment. Twenty-four thousand barrels of JP-4 was pumped through the line and 18 scrapers run with the line wash. Wash oil was delivered to a crude oil pipe line at Oklahoma City for return to the refinery for reprocessing. Cleaning this section of paraffin and obtaining product of good color required only 7000 bbl of JP-4; however, approximately 10 miles of the line had been in sour crude service intermittently and the remaining 17,000 bbl of wash was needed to leach the sulfur from the line so that the JP-4 would meet sulfur specifications.

Approximately $400,000 was spent on the conversion of the entire system, an average of about $620 per mile. This included conversion work required to isolate the lines used in product service from the crude oil lines and old crude line pump stations, the loss absorbed on product used for line wash, pumping costs including setting and removing temporary pump units, product loss through leaks, and line repairs.

Prior to cleaning one criteria was established: That the crude oil in the line would be displaced entirely by means of the line wash with no water being allowed in the line at any time. This was based on laboratory tests, which indicated that water would harden the paraffins and materially affect the solubility of the paraffins in the wash oil.

Since the completion of the system, connections have been made to three other pipe lines. A connection was made to the Oklahoma-Mississippi Pipe Line Company, Inc., at Drumright, Oklahoma, which makes possible the delivery of products from Cherokee to Oklahoma-Mississippi for delivery to terminals at Fort Smith, Conway, and West Memphis, Arkansas. The Texaco-Cities Service Pipe Line from Tulsa to Ponca City delivers products to Cherokee at Ponca City for movement to Wichita and Oklahoma City. A connection with Kaneb Pipe Line near Wichita enables Kaneb to deliver to Cherokee and will also enable Cherokee to deliver to Kaneb for movement north on Kaneb's system.

Pump Station Design

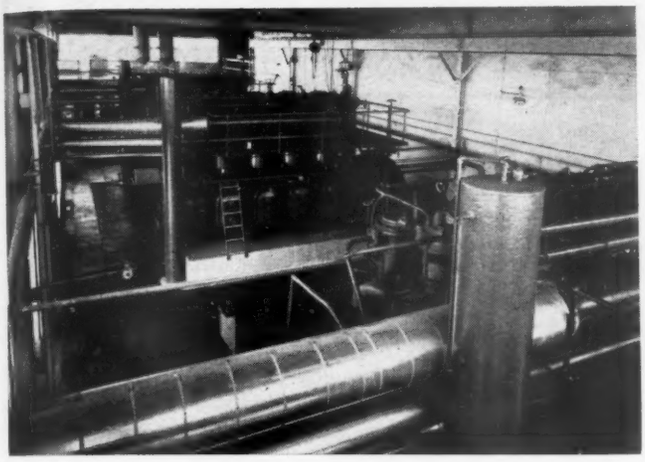
The three pump stations at Ponca City, Glenpool, and Mount Vernon are of similar design. The Ponca City station is in effect a double station with three motor-driven centrifugal units totaling 650 hp pumping products from Ponca City to Wichita, Kansas, while four motor-driven centrifugal units totaling 2100 hp pump south on the 8-in. line to Oklahoma City and to Mount Vernon and Wood River on the combination 8-in. and 10-in. line.

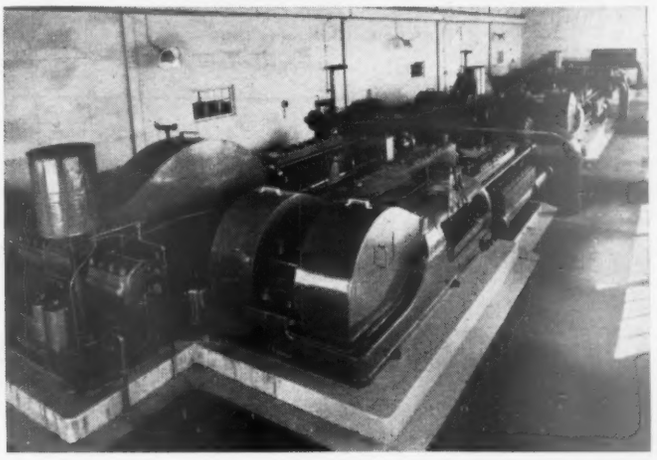
The Glenpool station is a relay station to Mount Vernon and consists of four motor-driven centrifugal units totaling 1000 hp. The Mount Vernon station is a relay station having three motor-driven centrifugal units totaling 900 hp.

A more detailed description of the Ponca City station will be given as it is the originating station on both systems and involves more control and measurement functions than the other two.

The station receives products from five remote booster pump locations, which are situated near the product tankage. The booster pumps are each set up so that a sequence operation activated by a single push button opens the valve in the tank suction line, starts the booster pump motor, and opens the station suction valve. There are sufficient interlocks on the motor operators so that as one stream is opened into the station, valves on other streams will close automatically. This is a definite aid in making product switches from the suction side of the station and the timing is set to minimize product contamination.

As the stream enters the suction side of the station, rust inhibitor is injected by an automatic proportioning system that receives its signal from positive displacement meters. The stream passes through self-cleaning type strainers having 200-mesh screens, then through the positive displacement meters. Each stream has a bank of three meters, interconnected so that any two will meter the stream with the third serving as a





Three views of Stotts station near Springfield, Missouri. Exterior at top of page, and diesel engines (above left) driving reciprocating pumps shown at right. The station has three 500-hp diesels for prime movers.

standby and also as a master meter for proving the other two. In addition a meter prover tank is provided for calibration purposes. These meters provide the measurement for custody transfer into the Cherokee system.

Each of the main line pumping units is controlled by a single start-stop button. The start button activates a sequence operation that includes opening the pump suction valve, venting the pump, starting the pump motor, and opening the pump discharge valve. The stop button deenergizes the motor and closes both valves simultaneously. Each pump and motor unit is equipped with sleeve bearings. High bearing temperatures are detected by a scanning type multi-record electronic unit that records each bearing temperature. A high bearing temperature or high pump case temperature activates an audible alarm and also shuts down the unit with a console desk light energized to indicate cause of the difficulty.

High motor winding temperature shutdown is provided by a thermal switch built into the windings by the motor manufacturer. Leakage of mechanical seals is detected by a float switch that gives an alarm signal.

Other station protective devices shut down the station for low station suction pressure, high pump case pressure on any unit, low pump suction pressure on any unit, and high station discharge pressure. These shutdown devices are all connected in such a manner that the units are shut down in sequence until the condition is brought within allowable limits.

The control valve on the discharge side of the station is connected through a 3-function control system. Station suction pressure, station discharge pressure, and motor load (kilowatt demand) are pneumatically linked so that the control valve position is governed by the variable deviating most from control setting.

The station is equipped with a console desk having a schematic plan of all station piping and equipment. The console contains lights to indicate valve position, warning lights on all protective functions, and push buttons for booster pump and main line pump starting and shutdown, as well as push buttons for horn reset, alarm tests, and emergency shutdown.

Remote reading automatic tank gages are provided as an aid to the station operator but are not utilized for custody transfer purpose.

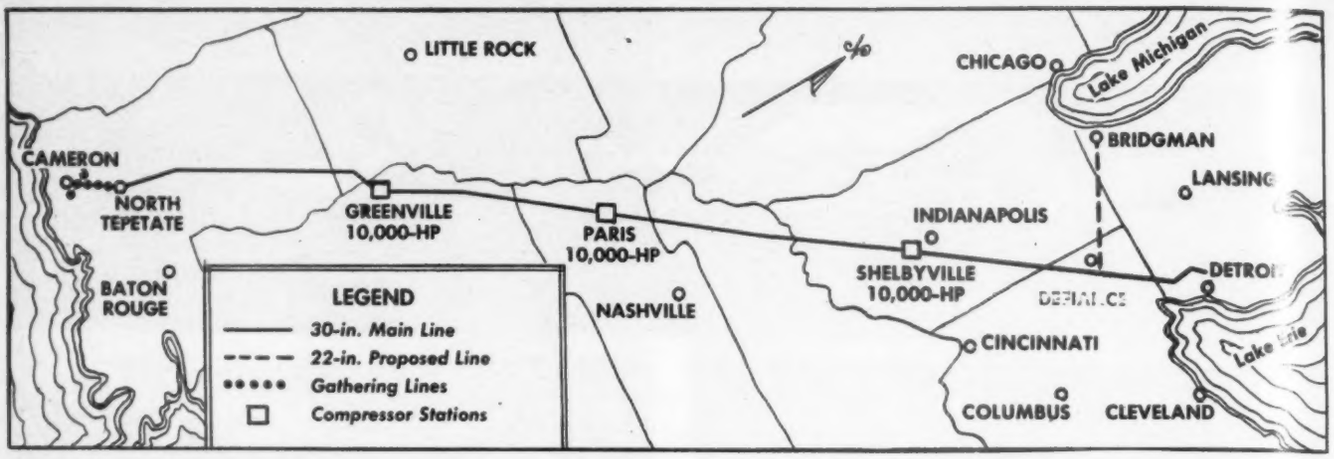
Delivery Facilities

As mentioned previously, the Cherokee system delivers to terminals at Wichita, Kansas, Oklahoma City, Oklahoma, Mount Vernon, Missouri, and Wood River, Illinois. Each delivery facility is equipped with a flow controller to regulate delivery rates, positive displacement meters with proving tanks, and self-cleaning type strainers. In addition, remote reading automatic tank gages and temperature gages are provided as an operating aid for the deliveryman.

The delivery points are equipped with indicating pressure controllers, which are utilized to stop flow gradually and maintain a predetermined "shut-in" pressure. Strainer differential pressure is measured with an electronic differential pressure seal and recorded. There are two set points on the differential pressure—the first activates a light while the second point, which is slightly higher, activates a horn.

Summary

Operation of the Cherokee products system was begun in November, 1954, utilizing temporary pumping units. First quality products were received in Wood River on December 28, 1954, and at Wichita on February 14, 1955. Deliveries were not made to Oklahoma City until April 6, 1955, as shippers did not have terminal facilities until that time. The permanent stations were placed on stream in May, 1955, with only minor difficulty being experienced. There were a few cases of improper electrical connection between field and control units and a few leaks in air and station piping; however, the stations were placed in operation with a minimum of difficulty and are operating most satisfactorily at this time. *



Map shows route of American Louisiana's 30-in. main line, gathering lines, and proposed 117-mile, 22-in. lateral from Defiance, Ohio, to Bridgman, Michigan.

Long Awaited American Louisiana Line Construction Underway

Construction Report

Over half of 1073-mile Detroit-South Louisiana transmission line to be built in 1955; three 10,000-hp stations planned for new system

FOLLOWING the awarding of contracts in mid-summer, work is underway on construction of American Louisiana Pipe Line Company's $130,000,000, 1073-mile natural gas pipe line system from South Louisiana to the Detroit, Michigan area.

Contractors for the new line include H. C. Price Company, Bartlesville, Oklahoma, and Houston Contracting Company, Houston, Texas, who will build 783 miles of the main 30-in. line in a joint venture; Brown and Root, Inc., Houston, Texas, prime contractors for construction of 217 miles of 30-in. and 73 miles of 6 through 24-in. laterals and gathering lines, and J. Ray McDermott and Company, Inc., Harvey, Louisiana, who will build all major river crossings for the system.

EXCLUSIVE

American Louisiana, a subsidiary of American Natural Gas Company, re-

Bending crew puts a curve into a joint of 30-in. near Slaughters, Kentucky, at beginning of line.

Pipe gang at work on main line in Kentucky. Four spreads will lay 30-in. this year.

ceived the green light recently from the FPC to start construction of its new system. Approval on the new line, which was proposed almost two years ago, was held up by litigation instituted by a competitive transmission company and delays resulting from disagreement between the FPC and the producers supplying the line with gas.

The new line will begin operations in 1956, with an initial daily capacity of 300,000,000 cu ft. Deliveries will be made to Michigan Consolidated Gas Company, and Michigan-Wisconsin Pipe Line Company, both American Natural subsidiaries, and Milwaukee Gas Light Company, Milwaukee distributor. Gas supplies in the quantity of 250,000,000 cu ft daily will originate at North Tepetate, in Acadia Parish of Louisiana, and throughout southern Louisiana. The principal suppliers are Stanolind, Superior Oil Company, Humble, Gulf, British-American, and Kerr-McGee.

Another 50,000,000 cu ft daily will be bought from Texas Gas Transmission Corporation, at a point near Slaughters, Kentucky.

In addition to the main 1000-mile, 30-in. system, and a 73-mile lateral from North Tepetate to Cameron, Louisiana, the company also plans a 117-mile, 22-in. line from Defiance, Ohio to Bridgman, Michigan, which is now awaiting FPC approval.

Three 10,000-hp compressor stations will be installed initially at Greenville, Mississippi; Paris, Tennessee, and Shelbyville, Indiana. Each station will have five 2000-hp reciprocating angle-type gas engine-compressor units. The three compressor stations will be installed in 1956.

Construction in 1955 will be at several points. H. C. Price Company will complete 185 miles in Kentucky and Indiana, with two spreads in operation, one working north from Slaughters, Kentucky and one working south from near Indianapolis, Indiana. Houston Contracting Company will also have two spreads on the project, one working south from Detroit and the other working north from the point near Indianapolis.

Work on the 383-mile section between Slaughters and the Arkansas-Louisiana border will begin in early 1956. Construction of the 217-mile section of 30-in. in Louisiana will get underway soon, as will the 73 miles of line south of North Tepetate. It is understood that Brown and Root is subcontracting this section.

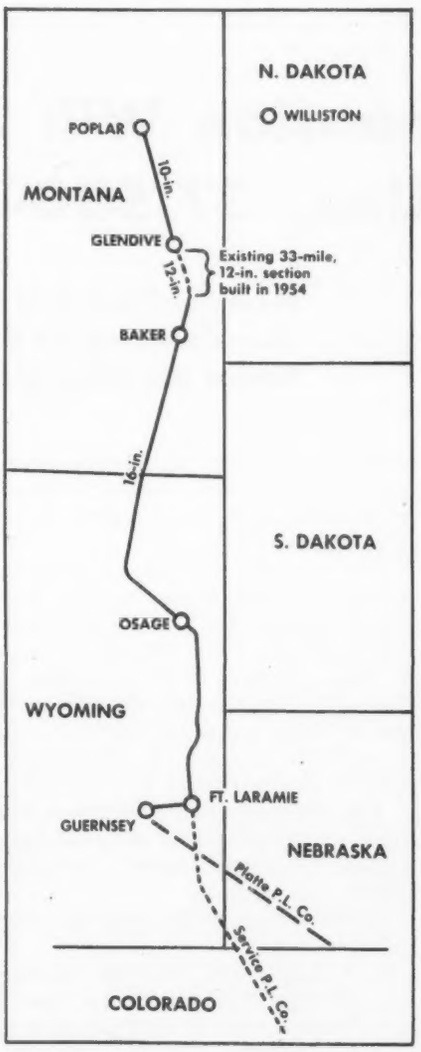
Initial work on the major river crossings including a crossing of the Mississippi near Greenville, Mississippi, has been begun by J. Ray McDermott and Company. * * *

Eastern Montana

Construction Report

Crude Outlet Provided By New Butte Line

EASTERN Montana crude production will have a new outlet to the Chicago and Wood River areas late this autumn, when the Butte Pipe Line Company begins operation of its 452-mile system from Poplar, Montana, southward to connections at Fort Laramie, Wyoming, with Service Pipe Line Company and at Guernsey, Wyoming, with Platte Pipe Line Company.



Map shows route of the 452-mile, 10, 12, and 16-in. Butte Pipe Line system. Shell Pipe Line is constructing and will operate the system for the owners.

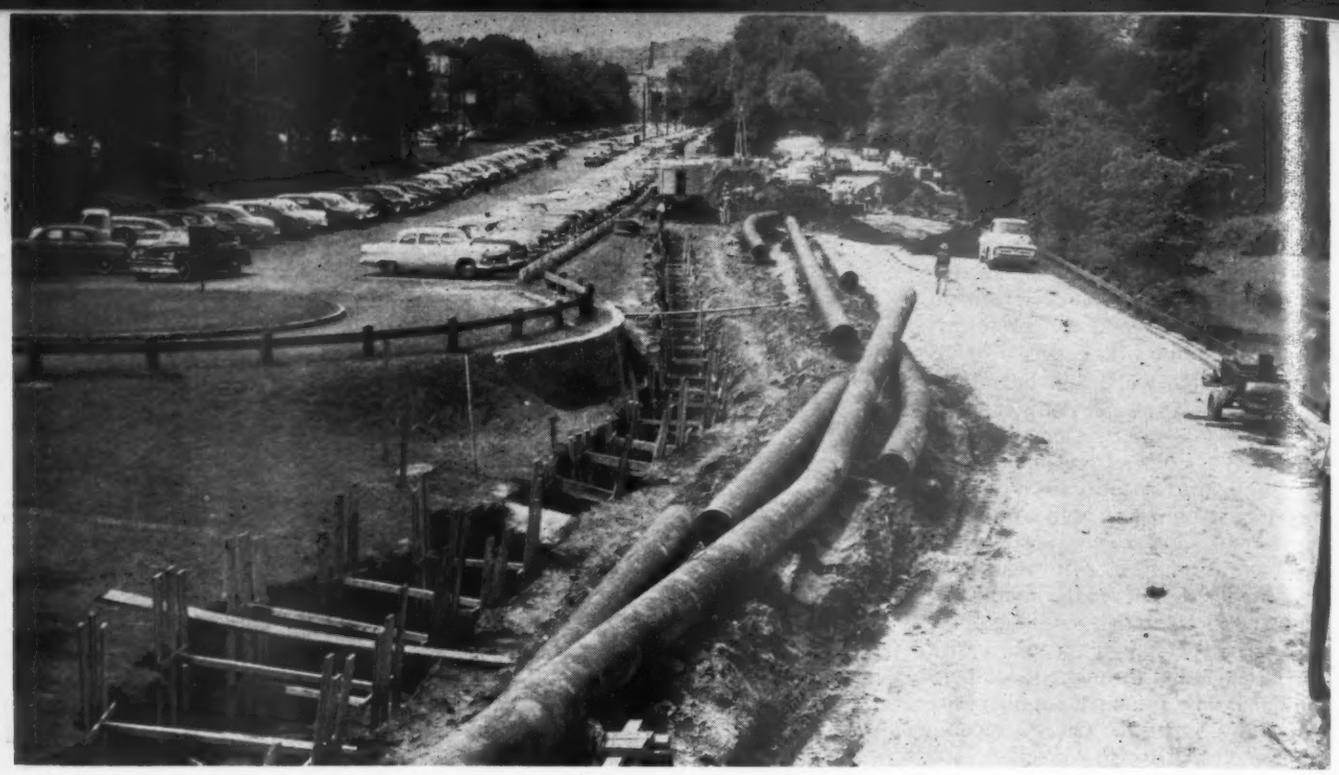
Work has been underway on the 10, 12, and 16-in. system since June, and completion has been set for October. Three contractors are laying the line. They are Anderson Brothers Corporation, Houston, who are laying 82 miles of 10-in. and 6.5 miles of 12-in., including crossings of the Missouri river about 13 miles from the start of the line, and the Yellowstone river, a major tributary of the Missouri; O. R. Burden Construction Company, Tulsa, laying 15 miles of 12-in. and 88 miles of 16-in.; and Associated Pipe Line Contractors, Houston, who are building 227 miles of 16-in. and a 10-mile, 16-in. leg from Ft. Laramie to Guernsey.

To be incorporated into the line will be a 33-mile, 12-in. section between Glendive and Cabin Creek, constructed in 1954. The line will tap four fields—Poplar, Glendive, Pine Unit, and Cabin Creek—and run close by several others in the North Dakota-Montana area.

Three stations are planned on the new line, all with motor-driven centrifugal units. At Poplar, 275-hp will be installed for the initial injections into the system. At Baker, Montana, a second station will have 1800-hp and a third station will be located at Osage, Wyoming, with 1300-hp.

In Montana, the line runs through mostly rolling, hilly prairie land. From the Montana-Wyoming border, the line climbs up through the Black Hills National Forest in fairly rugged terrain, and then descends from Osage enroute southward. The 10-mile leg between Ft. Laramie and Guernsey will cross the North Platte River and U. S. Highway 26.

Butte Pipe Line is a joint venture of Shell Oil Company, Placid Oil Company, and Murphy Corporation. The line is being engineered, constructed, and will be operated by Shell Pipe Line Company, acting as agents for the owners. * * *



Citizens of White Plains, New York, had a first hand opportunity to watch pipe line construction where this section of the Hebron-Greenwich line skirted their municipal parking lot.

P 623

Construction Report

TGT's 1955 Expansion Will Add 734 Miles of Line, 37,500-hp

New facilities will give Tennessee Gas Transmission Company an 8911-mile, 545,082-hp system; future planning includes 1647 miles of new line

George O. Jackson
Tennessee Gas Transmission Company
Houston, Texas

TENNESSEE GAS TRANSMISSION COMPANY neared the end of its 11th year of operation—October 31—with two major pipe line construction projects underway and four smaller jobs completed.

This year's construction program is designed to give TGT, already operator of one of the nation's major natural gas systems, 734 more miles of pipe line.

On top of that, 1955 found the company initiating six compressor station projects—the construction of two new stations and additions to four others.

Also, Federal Power Commission hearings were held on an application for even further expansion. This project embraces plans for 221 miles of loop lines in Kentucky and Ohio; 376 miles of gathering lines in Louisiana and Texas; the construction of two new compressor stations, and the expansion of an existing station.

And the company recently announced that an application will be made to the FPC to construct a 1050-mile pipe line from the Canadian border near Emerson, Manitoba, to its main multiple-line system near Nashville, Tennessee.

This new line is proposed as the result of a contract signed by TGT with Trans-Canada Pipe Lines Limited for the purchase of 200,000,000 cu ft of natural gas daily, with an option to buy an additional 200,000,000 cu ft per day when and if that extra amount is available at Emerson. This importation will also require FPC approval.

The 1955 construction program will raise the TGT system daily delivery capacity to approximately 1,694,500 MCF.

A breakdown on the program is as follows:

1. A 24-in. line from the Hebron Storage Field at Coudersport, Pennsylvania, to near Greenwich, Connecticut. This 250-mile project was started in May.
2. A 370-mile, 30-in. line from the company's southernmost compressor station at Agua Dulce, Texas, to Kinder, Louisiana. Contracts for this work were let in August.
3. A 20-in. gathering line in South Central Louisiana, from Kinder to Pecan Island, a distance of 58 miles.
4. 25 miles of loop line from Mercer, Pennsylvania, southwestward and 12 miles of loop line near McConnellsville, Ohio. These 26-in. loops are part of the company's main line system.
5. A 19-mile, 24-in. line from the storage field at Harrison, Pennsylvania, to the Coudersport compressor station.
6. Two new compressor stations—one of 13,400-hp near Morehead, Kentucky, and the other of 5500-hp at Isola, Mississippi.
7. The enlargement of four compressor stations: Winchester, Kentucky, 6000-hp; Albany, Ohio, 4000-hp; Coudersport, 6600-hp; Hamburg, New York, 2000-hp.

EXCLUSIVE

At the beginning of the year, the TGT system had 8177 miles of pipe line and 507,582 installed compressor horsepower.

"Loop" Extends 1000 Miles

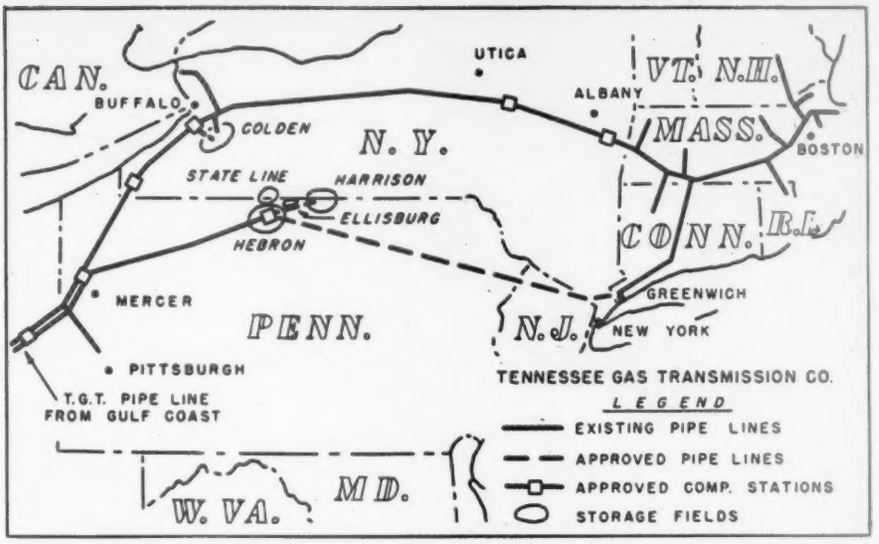
The Hebron-Greenwich pipe line will serve, principally, the New York City-Northern New Jersey metropolitan area. Running 250 miles across Pennsylvania, New Jersey and New York, it will tie in near Greenwich, Connecticut, with the south end of the company's system in New England.

When in service, it will give the company a 1000-mile, five-state "loop" that will furnish TGT's New England customers a new, alternate route of supply as well as giving the New York City area its first TGT service.

Normally, gas will be routed in two directions from Mercer, Pennsylvania, where the company's main line system forks. One prong of this fork goes northward near Buffalo, New York, to Springfield and Gloucester, Massachusetts, and into New Hampshire, with a leg extending southward from Springfield through Connecticut to Greenwich. The other prong runs from Mercer to the Hebron Storage Field and, upon completion of the new 250-mile line, will tie in at Greenwich, completing the "loop."

If necessary, New York City area customers could be served through the northern perimeter of the "loop." Conversely, the New England area could be supplied by means of the Mercer-Hebron-Greenwich portion. In this way, the company will be able to deliver gas from either of two directions to any point on the "loop."

Construction-wise, two portions of the Hebron-Greenwich line have presented problems of particular interest. These are the Hudson River crossing near Dobbs Ferry, New York, and the section in heavily-populated Westchester County, New York.



Map shows location of 250-mile Hebron-Greenwich line that completes a 1000-mile "loop" for TGT in the Northeast.

Hudson River Crossing

The Hudson is flanked on the west by the Palisades, 150 feet high. And at the crossing—about 7100 ft long, including the west bank marshland—the river has a main channel depth of 50 ft. Plans called for the two 24-in. lines to be laid 25 ft apart and 25 ft below the river bottom in the main channel, as opposed to an ordinary river crossing depth of five to 15 feet.

Because of the precipitous slope of the west bank special means of launching the pipe into the river had to be considered. Engineers for the company and the contractor, the Bechtel Corporation, settled on this plan:

The pipe, pre-coated with a 3½-in. thick cement and illemenite ore mixture would be welded into 860-ft sections in a makeup area atop the bluff overlooking the crossing; the joints X-rayed and coated, and the sections capped and hydrostatically tested.

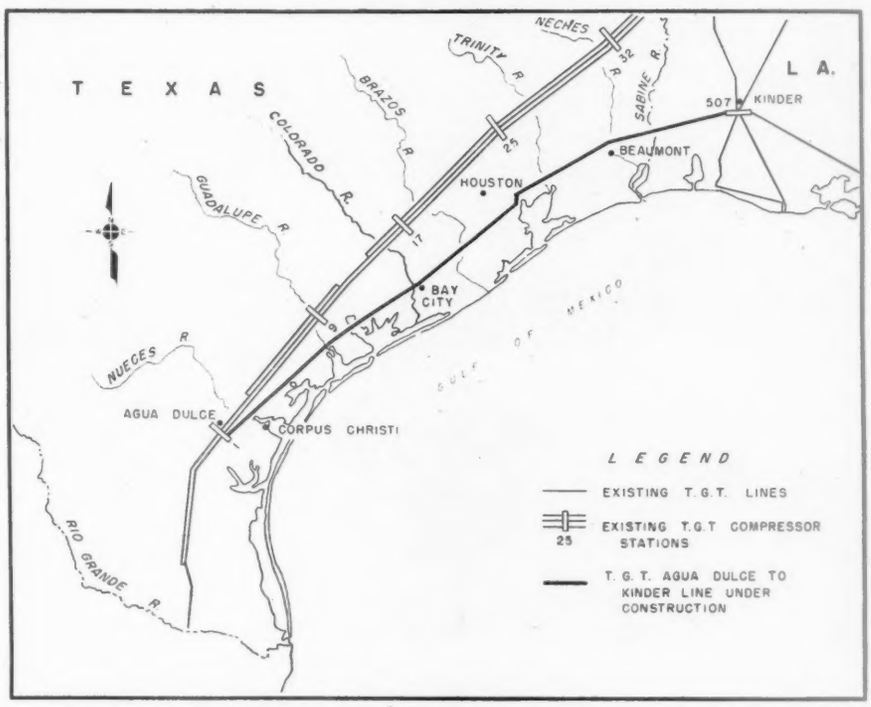
Then each section, fitted with buoys spaced every 53 ft, would be rolled onto a launching ramp fitted with rubber-tired wheels and extending 600 ft downward to the water's edge, with a maximum slope of 25 degrees. A radius of at least 1200 ft would be maintained in the curvature of the ramp so as to avoid undue stress on the pipe and its coating. On the slope the ramp would be laid on grade, while at the bottom of the bluff it would be supported by fill and pilings.

After one 860-ft section cleared the makeup area, another section would be tied on. The pipe would be pulled by winch from the east bank, with a holdback winch at the makeup area maintaining enough restraint for control.

Upon completion of the pulling operation, the buoys would be cut loose and the pipe allowed to settle into its permanent position.

The crossing, utilizing this plan, was scheduled to begin during the latter part of September.

Preliminary work on the Hudson River crossing included the removal of a 1650-ft-long "T-head" pier, made of rock and pilings, and a sunken concrete barge. At one time, tankers serving a now-abandoned oil company tank farm on the west bank used the pier.



Map shows location of the 370-mile Agua Dulce-Kinder line following the Texas Gulf Coast. It is now under construction.

Pipe gang works up-hill on western end of the Hebron-Greenwich line in western Pennsylvania.

The barge, apparently also used for oil transport, rested on the bottom near the end of the pier. It was sealed, pumped out and raised, towed to sea and sunk.

"Suburban Pipelining"

The problem in Westchester County was one caused by a lack of open country for pipe line right-of-way. Suburban development made it necessary to follow county-owned land wherever possible so as to forestall any outsized disturbance of private property.

Consequently, one section of the line, in and near White Plains, New York, will rest in a ditch dug down the middle of one traffic lane of the Bronx River Parkway, which links Westchester County with New York City. In the same area, the right-of-way crosses the Bronx River five times in 1½-mile stretch.

Also in that area, the contractor had to keep a close watch for and lay plans for circumventing a veritable grid of utility lines.

Other heavily-traveled thoroughfares lying along the line's route in Westchester County include the Saw Mill River, Central Westchester and Hutchinson River Parkways, and Westchester Avenue.

Right-of-way was acquired from the Westchester County government for this section of the Hebron-Greenwich line. Shown here is section of ditch being dug down middle of a traffic line of busy Bronx River Parkway, main artery to New York City.

The contractors for western portions of the Hebron-Greenwich line completed their work by the end of July. H. C. Price Company laid 50 miles, starting from Coudersport. Another 109 miles, taking up where the Price company left off, were built by the Oklahoma Construction Company. Oklahoma's work also included construction of the Susquehanna River crossing, which was completed in July.

The August 18 cloudburst and subsequent flood in Pennsylvania and New Jersey plagued the Bechtel Corporation and Pentzien, Inc., contractors for the remainder of the line. Pentzien, Inc., contractor for the Delaware River crossing, was just about ready to pull pipe when the rains came, and the Bechtel Corporation lost some of its ditch in the flood.

Pipe line district headquarters being set up along the line are near Troy, Pennsylvania, near Nicholson, Pennsylvania, and near Ramsey, New Jersey. A pipe line warehouse, office and radio tower will be maintained at each location.

New Coastal Line

The 370-mile Agua Dulce-Kinder pipe line now under construction will run parallel to and near the Gulf of Mexico coastline, cutting across a coastal sector that has significant supplies of natural gas, from the standpoint of both onshore and offshore operations.

A substitute in part for previously-authorized but never built loops along the main system between Agua Dulce and Natchitoches, Louisiana, the new 30-in. line will tie in at Kinder with a 30-in. line that TGT built in 1954 from Kinder to Portland, Tennessee.

The Agua Dulce-Kinder line's route entails nine major water crossings. The Lavaca Bay crossing, about 29,000 ft, will be the longest submerged crossing ever made by a TGT main line. The other major crossings, all to be submerged also, will be constructed at the Guadalupe, Colorado, Brazos, Trinity, Neches and Sabine Rivers; the Houston Ship Channel, which is flanked by San Jacinto and Tabbs Bays, and Cedar Bayou, near Baytown, Texas.

Across the Ship Channel, route of ocean liners from the Gulf of Mexico to the Port of Houston, a ditch depth of 50 ft below the surface of the water, or 16 ft beneath the channel bottom, will be necessary.

Contractors for the Agua Dulce-Kinder line are Morrison Constructors, Inc., Williams Bros., Houston Contracting Company, H. C. Price Com-

pany, Western Constructors, N. A. Saigh Company, Panama-Williams Company, and Associated Pipe Line Constructors, Inc.

Pecan Island Lateral

TGT's major gathering line project of the year was the 58-mile, 20-in. pipe line laid from Kinder southward to Pecan Island, near the onshore terminal of a submarine pipe line from the Pure Oil Company's Rollover Field in the Gulf of Mexico.

For about half its length, the Pecan Island line had to be laid under water. Houston Contracting Company used barges during construction wherever possible, while at other points sections of pipe were literally shoved along water-filled ditches from islands built along the marshy right-of-way.

Where shoving was necessary, the cement-coated pipe was four-jointed at the shove point and four empty 55-gal oil drums were fastened, with metal box straps, to each 40-ft joint. Then the 160-ft long sections were welded into the line and launched by winch tractors. The barrels provided the buoyancy needed to float the line during construction. Afterwards, workmen in boats cut the drums loose and the pipe line, weighted by its coating of cement, sank into its water-filled trench. The longest section of the pipe line laid in this manner was 31,000 ft.

Where barges were used, four of them were coupled together, providing six work stations — two for lineup, stringer bead and hot pass, two for welding and two for coating. Two single joints of pipe were added at a time. The pipe was supported on the barges by rubber-clad tracks made from war surplus half-tracks.

Other Facilities

The loop lines built near McConnellsville, Ohio, and Mercer, Pennsylvania, by H. C. Price Company, gave the company two 26-in. lines from the Ohio River to Mercer.

Completion of a 24-in. line from the Harrison Storage Field to the Coudersport, Pennsylvania, compressor station will enable the company to develop its third storage facility. The other two are the nearby Hebron field at Coudersport and the Colden Field near Buffalo.

The storage program, operated in conjunction with the 1000-mile "loop" afforded by completion of the Hebron-Greenwich pipe line, will provide TGT's customers with extremely dependable and flexible service.

Plans for the new Morehead, Kentucky, compressor station called for the installation of two 6700-hp gas turbines, while the new station at Isola, Mississippi, will operate with five 1100-hp engine-reciprocating units.

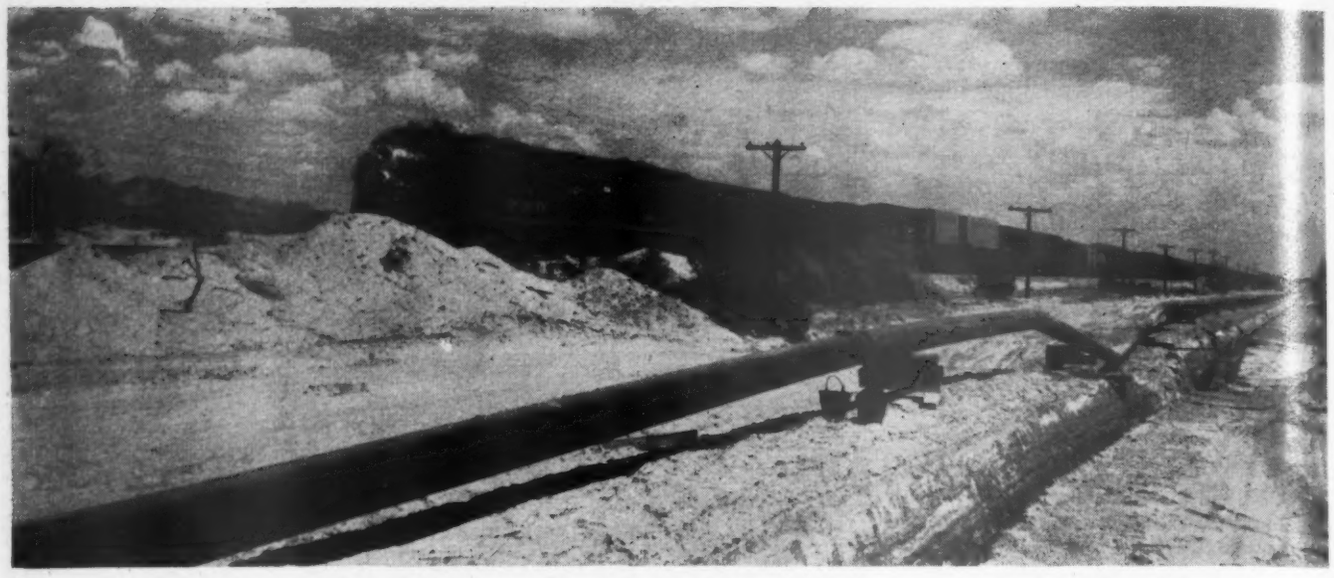
Concrete-coated pipe sections were shoved into the water-filled ditches on the Pecan Island gathering line. Barrels, tied to the line for added buoyancy during the shoving operation, were later cut loose and line sank slowly to bottom of swampy ditch.

Three units of 2000-hp each are being added at Winchester, Kentucky, and two similar units are going in at Albany, Ohio.

The Coudersport station was being expanded by 6600-hp (five 1320-hp units) and the enlargement of the station at Hamburg, New York, involved the installation of two 1000-hp engines.

Completion of the 1955 construction program will mark a two-year period of impressive growth for TGT. During 1954, the company laid the 576-mile, 30-in. pipeline—from Kinder, Louisiana, to Portland, Tennessee—to which the new Agua Dulce-Kinder line will be tied; built 130 miles of 26-in. loop line in Ohio, and constructed a 45-mile line from near Buffalo, New York, to the Niagara River, through which service to Toronto, Canada, was initiated. A new compressor station was installed at Coudersport and two other stations were enlarged. * * *

Road crossings, though no problem for pipeliners, were numerous on some sections of the Hebron-Greenwich line. This crossing for the 24-in. line was in Pennsylvania.



Southern Pacific freight train passes the company's new products pipe line under construction on adjacent right-of-way.

Construction Report

Texas-California Products Line Nears Completion

J. B. Stumm
West Coast Editor

New 847-mile, $30,000,000 products system built by railroad company on its own right-of-way between El Paso and Los Angeles to be ready in December

THE first common-carrier products pipe line ever to be constructed by a railroad on its own right-of-way in this country is making on-schedule progress as it wends its way through the torrid desert country lying between Los Angeles, California, and El Paso, Texas.

Southern Pacific Pipe Lines, Inc., a subsidiary of Southern Pacific Company, is building the unique 847-mile pipe line system to carry petroleum products—regular, premium, and aviation gasoline; diesel oil, and jet fuel—from refineries in Los Angeles and El Paso to the fast growing markets in the populated areas of Arizona.

There are presently no refineries in Arizona, and the Southern Pacific Company, with its inherent advantage of its own private right-of-way, will be in a position to serve all companies distributing petroleum products in those parts of Arizona contiguous to Southern Pacific rail lines. Because of transportation rate savings, as pointed out by a California oil company executive, the line will permit his company to reduce the price of gasoline by about 1½ cents per gallon for Phoenix and Tucson, with corresponding reductions elsewhere in the areas to be served by the line. Similar price reductions in other products carried by the line will also be affected.

Route of the Line

The pipe line generally follows the railroad right-of-way from Los Angeles to Phoenix and Tucson, serving the important intermediate areas of Colton, the Imperial Valley and Yuma. The route followed between Tucson and El Paso is the shortest practical one, using the railroad right-of-way where it is economically practical.

Exact route of the pipe line, as shown on the accompanying strip map, is from Watson (Los Angeles) to Colton, then to Yuma and Phoenix, via Hassayampa. From El Paso to Phoenix, the line passes through Lordsburg, New Mexico, and Tucson.

The pipe line will make six major river and canal crossings by suspension spans. They include: The Rio Grande River, 280 ft; the San Pedro River, 1020 ft; the Colorado River, 840 ft; the All-American Canal 440 ft; the Yuma Main Canal, 240 ft, and the Coachella Canal, 280 ft.

Size and Capacity of Line

The line will consist of a 16-in. section from Watson to Colton, 62 miles, with a capacity of 42,000 bbl per day at 600 psi; a 12-in. line from Colton to Phoenix, 356 miles, with a capacity of 36,000 bbl per day at 1350 psi, and an 8-in. line from El Paso to Phoenix, 424 miles, with a capacity of 13,600 bbl per day at 1320 psi.

There will be three pump stations on

Map shows route of line and pipe diameters on the 847-mile system.

the line, at Watson, Colton, and El Paso. The Watson Pump Station will consist of three four-stage, 4 by 6 by 11 horizontal-shaft, split-case, double-volute centrifugal pumps driven by three 300-hp, 2300 v, 3600-rpm synchronous speed induction motors.

Colton Pump Station will consist of three five-stage, 6 by 8 by 11 horizontal-shaft, split-case, double-volute centrifugal pumps driven by three 900-hp, 2300 v 3600-rpm synchronous speed induction motors.

El Paso Pump Station will have two five-stage, 3 by 4 by 10 horizontal-shaft, split-case, double volute centrifugal pumps driven by two 300-hp, 2300 v, 3600-rpm synchronous speed induction motors.

Construction Progress

With final approval of the project by the board of directors of the Southern Pacific Company late in February, initial planning and design of the pipe line was begun by Engineering Management, Inc., in Los Angeles, on March 1, 1955, under the direction of D. L. Roberts, vice president and project manager. In order for the system to be completed and in operation by December 31, 1955, actual line construction was divided into eight schedules, awarding separate contracts on each.

Construction Data

All pipe for the entire line is being supplied by Kaiser Steel Corporation of Fontana and Basalt, California, and National Tube Company, Lorain, Ohio.

Pipe wall thickness varies from 7/32-in. to ⅜-in. The 16-in. and 8-in pipe is 5LX4200 and the 12-in. is 5LX4600. All welds are checked by X-ray and gate valves are being installed at approximately 20-mile intervals with others at key points. Hydrostatic testing of the line is to 90 per cent of yield.

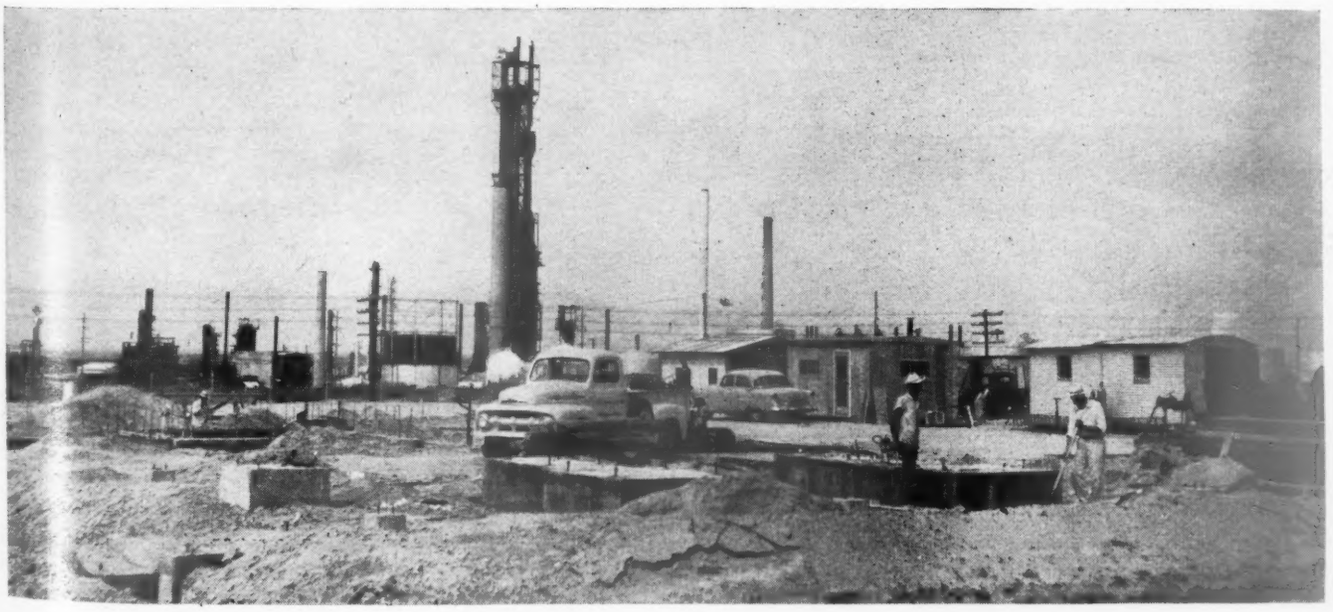
Stringing of pipe is being handled from unloading points by trucks, and the pipe is welded and wrapped as laid, except for the 16-in. pipe, which is being coated and stored at Watson. The 12-in. and 8-in. pipe is asphalt coated and glass fiber inner wrapped. The outer wrap on the 12-in. is glass fiber and the outer on the 8-in. is felt. The 16-in. pipe is all Somastic coated.

Soil conditions along the route vary from loam to sand with some caliche and about 2 per cent rock. The terrain is mostly desert with some mountainous. Generally, the pipe is being cradled into the ditch with slack loops at 400 to 600 ft. Normal cover on the pipe is 30-in. with extra depth in certain agricultural areas and adjacent to railroad tracks.

Take-Off Points

Take-off terminals will be at Colton and Niland, California, on the western line and at Tucson, Arizona, on the eastern line, with the terminal for both lines at Phoenix. Phoenix terminal fa-

Foundations under construction near El Paso for the pumping station at east end of the new 847-mile line.



New type coating and wrapping machine — a hydraulic, self-cradling unit powered by engine on dope kettle followed by a recirculating water-spray ring-type cooler — received its maiden run on the Macco-Robertson spread.

Crew attaches hose lines to temporarily sealed pipe end for an intermediate air test near Yuma, Arizona. Line will later be hydrostatically tested to 90 per cent of yield point.

cilities are to be constructed on approximately 60 of 112 acres of newly acquired property fronting on Van Buren Street and 51st Avenue. Purchased by Southern Pacific Company, the land is in Maricopa County territory of SP's main rail line into Phoenix from the west. Tank farms and receiving points for as many as eight shippers will be established on the 60 acres, the balance of the property being held for future industrial development.

Approximately 40 acres of land near Davis-Monthan Air Base have been optioned for the Tucson terminal.

Officers of Southern Pacific Pipe Lines, Inc., the Southern Pacific Company subsidiary that will operate the completed line, are D. J. McGanney, president; E. E. Mayo, vice president, and F. E. Kalbaugh, general manager.

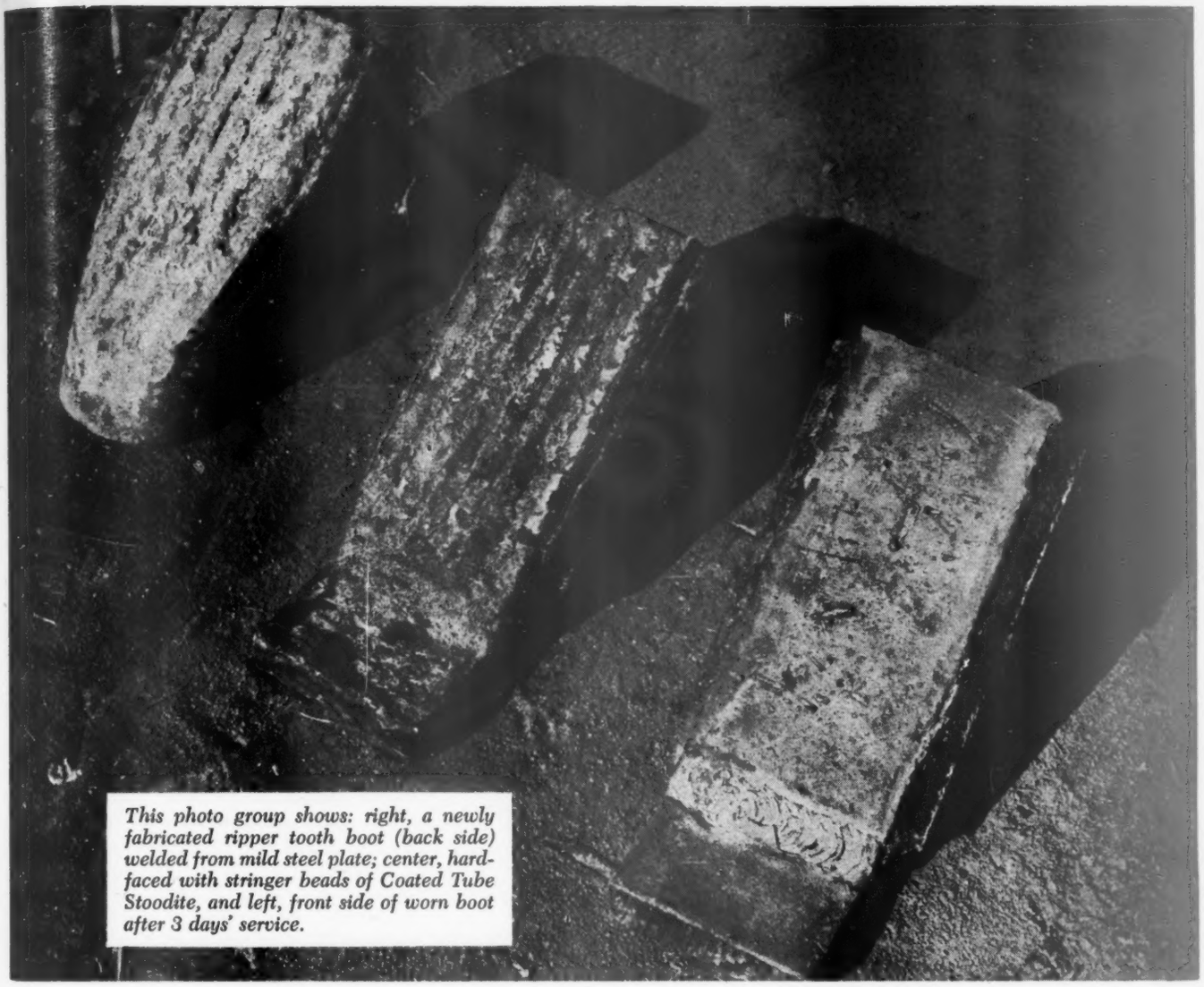
Line Construction.

Schedule 1	Lordsburg, New Mexico, to El Paso, Texas — 159 miles of 8 in. pipe.	Morrison-Knudsen Company, Inc., Los Angles, California.
Schedule 2	Lordsburg, New Mexico, to Tucson, Arizona — 144 miles of 8 in. pipe.	R. H. Fulton & Company, Lubbock, Texas.
Schedule 3	Tucson to Hassayampa River, Arizona — 122 miles of 8 in. and 35 miles of 12 in. pipe.	Hood Construction Company, Lynwood, California.
Schedule 4	Yuma, Arizona, to Hassayampa River — 127 miles of 12 in. pipe.	Macco Corporation and Alex Robertson Company, Paramount, California.
Schedule 5 & 6	Yuma, Arizona, to Colton, California — 195 miles of 12 in. pipe.	Conyes Construction Corporation, San Pablo, California.
Schedule 7	Colton, California, to LaHabra, California — 43 miles of 16 in. pipe.	J. E. Young Pipe Line Contractor, Inc., Los Angles, California.
Schedule 8	Watson, California, to LaHabra, California — 19 miles of 16 in. pipe.	Engineers Limited Pipe Line Company, Los Angles, California.

Other Contracts.

El Paso Pump Station	Robert E. McKee General Contractor, Inc., El Paso, Texas.
Colton Pump Station	J. H. Pomeroy & Company, Inc., San Francisco, California.
Watson Pump Station	J. A. McNeil Company, Inc., Alhambra, California.
Rio Grande River and Coachella Canal spans	Associated Pipe Line Contractors, Inc., Houston, Texas.
San Pedro River Span	Ashton Building Company, Tucson, Arizona.
Colorado River, Yuma Main and All-American Canal spans.	Morrison-Knudsen Company, Inc., Los Angles, California.
Tankage	
El Paso, Watson, and Niland terminals	Chicago Bridge & Iron Works.
Phoenix and Tucson terminals	Consolidated Western Steel Division, United States Steel.
Colton terminal	Southwest Welding & Manufacturing Company, Alhambra, California.

Water at Yuma — too much of it in photo at left, caused serious delay at times. Extremely heavy rains, unusual for desert country, deluged area. Pumps are shown here draining a flooded section of ditch. At right is portrayed a common sight in the hot arid country — a trip to the water cooler, welcome relief when the thermometer hit 115 degrees in the vicinity of Yuma.

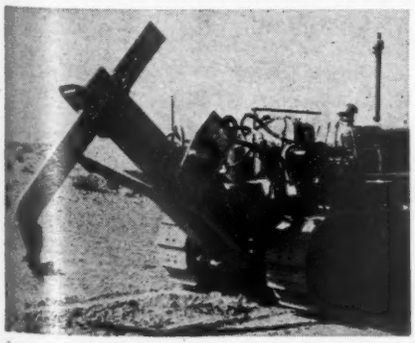


This photo group shows: right, a newly fabricated ripper tooth boot (back side) welded from mild steel plate; center, hard-faced with stringer beads of Coated Tube Stoodite, and left, front side of worn boot after 3 days' service.

HARD-FACED RIPPER TOOTH

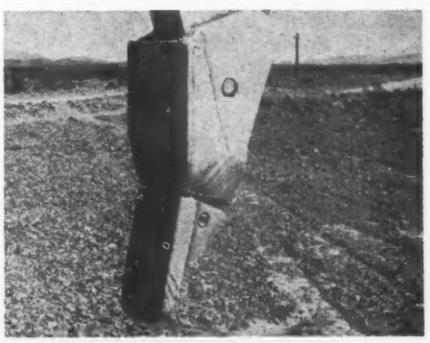
Lasts 1200% Longer on Desert Duty!

Near Ludlow, California, PG&E is spanning the vast Mojave Desert with a gas pipeline. To ease the trenching job a gigantic ripper is towed by a D7 tractor ahead of the ditcher. Its purpose is to break up the hard-packed earth and locate the frequent sub-surface lava flows. This lava is so hard and tightly bonded that explosives must be used to break up the formation.



Depth at which ripper operates is evident by length of standard.

The ripper on this job is designed for easy maintenance; boot type point and adapter are replaceable. The points are fabricated from mild steel plate in the division headquarters maintenance shop of the pipeline company handling the job, Engineers Limited Pipeline Co., Bakersfield, California. All four sides are hard-faced with Coated Tube Stoodite before being placed in service.



Close-up shows point attached to tooth adapter. Entire tooth is hard-faced with Coated Tube Stoodite.

Working deep in the highly abrasive earth, unprotected boots last only 2 hours. When hard-faced with Coated Tube Stoodite this short life is extended to three full days—an increase of 1200%.

Coated Tube Stoodite is a recent Stoody development for manual application, combining high wear resistance, good impact strength, fast deposition and low cost. Ask your Stoody dealer for details (consult the yellow pages of your phone book) or write direct.

STOODY COMPANY
11955 East Slauson Avenue
Whittier, California

The Petroleum Engineer's

1955-56 Pipe Line Contractors Directory

Here is an up-to-date listing of both general and specialized pipe line contracting companies. Given are the firm names, addresses, telephone numbers, and chief contact in each company, as furnished by the companies themselves. The first three pages are lists of those firms that do general pipe line contracting. Specialized firms are listed on the last two pages.

A. B. C. Construction Company, Inc.
12420 South Bollmfield Avenue
Norwalk, California

E. K. Aldridge & Sons, Inc.
P. O. Box 692
Athens, Ga.

Altgelt Construction Company, Inc.
3502 Lawrence Drive
Box 1402
Corpus Christi, Texas

Anderson Brothers Corp.
Box 8157
Houston 4, Texas
Telephone: JAckson 3-4323
Carl C. Anderson, President

Arey Construction Company
Box 1501
Pampa, Texas

John A. Artukovich Sons, Inc.
16200 South Atlantic Avenue
Paramount, California

Associated Pipe Line Contractors, Inc.
3272 Westheimer
Box 13216
Houston 19, Texas
Telephone: JAckson 4-7561
John M. Gay, Vice President and General Manager

Associated Pipeline, Inc.
509 Mayfair Road
South San Francisco, California

B & B Contracting Company
Box 30
Eldorado, Kansas

B & M Construction Company
1501 Republic Building
Oklahoma City, Oklahoma

Baker Contracting Company, Inc.
Route 4, Box 929
Shreveport, Louisiana

Ray D. Baker Contractor, Inc.
19200 West Eight Mile Road
Detroit 35, Michigan

Banister Construction, Ltd.
409 Northern Hardware Building
Edmonton, Alberta, Canada

Barry Construction Company
4108 Old Spanish Trail
Houston, Texas

C. P. Bartley & Son
Box 616
Tioga, North Dakota
Telephone: 4-2214
C. P. Bartley, Sr., President

Bates & Dungey, Inc.
Sparta, Illinois

Baughman Contracting Company, Inc.
Rt. 1, Box 569
Cumberland, Maryland

Bechtel Corporation
220 Bush Street
San Francisco 4, California

Bills Construction Company
1748 E. 13th Place
Box 644
Tulsa, Oklahoma

Henry Borger & Son, Ltd.
590 Pembina Highway
Winnipeg, Manitoba, Canada

Boyle Construction Company
Sumter, South Carolina

Brodie Construction Company
Box 2064
Amarillo, Texas

Brown & Root, Inc.
4100 Clinton Drive
P. O. Box 3
Houston, Texas
Telephone: FAirfax 3-7121
L. E. Minor, Manager

Buchanan Pipe Line Company, Inc.
Box 1903
Birmingham, Alabama

O. R. Burden Construction Corp.
6702 East 21st Street
Box 5216
Tulsa, Oklahoma
Telephone: TEmple 8-3378
O. R. Burden, President

Canadian Bechtel, Ltd.
44 King Street West
Toronto, Ontario, Canada

Canadian Construction Company, Ltd.
Box 280
Leduc, Alberta, Canada

C. P. Carter Construction Company
Box 928
Duncan, Oklahoma

C & R Constructors, Inc.

C. Hubert Gragg Construction Company
223 Britton Road
Oklahoma City 14, Oklahoma

Colorado & Wyoming Construction Company
Box 211
Loveland, Colorado

Comstock, Ltd.
206 Laird Drive
Comstock Building
Toronto, Ontario, Canada

Conner & Lasater Construction Company
Box 1025
Odessa, Texas
Telephone: 7-0482
Jack A. Conner, President

Consolidated Gas & Service Company
327 LaSalle Street
Chicago 4, Illinois
J. C. Donnelly, President

Construction Service Company
Lincoln Blvd. at Cedar
Box 311
Bound Brook, New Jersey
J. J. Senesy, President

Contracting & Material Company
1235 Dodge Avenue
Evanston, Illinois
Telephone: GR 5-6960
Richard D. Cagney, Vice President

Conyes Construction Corp.
13685 San Pablo Avenue
San Pablo, California

Corbett Contracting Corp.
Ferguson Building
Rawlins, Wyoming

Cumberland Contracting Company, Inc.
Monticello, Kentucky

A. J. Curtis Construction Company
Box 2009
Casper, Wyoming

Mitchell Darby Construction Company
Box 447
Pharr, Texas
Telephone: ST 7-3481
Mitchell Darby, President

B. J. Davis Construction Company
Box 117
Ashland City, Tennessee

George W. Davis Construction Company
1414 N. Eastern
Box 186
Oklahoma City, Oklahoma

The Petroleum Engineer's 1955-56 Pipe Line Contractors Directory . . .

Donaldson Construction Company
Dodge Center, Minnesota

Dutton-Williams Brothers, Ltd.
Pacific Building
Calgary, Alberta, Canada
Telephone: 69-2669
M. A. Dutton, President

Eastern Pipe Line Contractors
820 Mercantile Building
Dallas, Texas
Telephone: RIverside 4081

Engineering-Construction Company
402 North Cheyenne
Tulsa, Oklahoma

Engineers Limited Pipeline Company
225 Bush Street (General Office)
San Francisco 4, California
Telephone: GArfield 1-2980

John D. Fahey and Son, Inc.
306 First National Bank & Trust Building
Waynesburg, Pennsylvania

L. E. Farley, Inc.
5247 Buffalo Speedway
Houston, Texas

Ferguson Construction Company
Box 127
Eunice, New Mexico

Fish Pipe Line Construction Company
796 M & M Building
Box 2617
Houston, Texas

C. Wayne Fowler
Box 368
Cotton Valley, Louisiana

George W. Fowler, Contractor
Drake Building
Box 386
Minden, Louisiana

Fulghum Contracting Corporation
Box 1181
Harrisburg, Pennsylvania

R. H. Fulton & Company
Box 1526
Lubbock, Texas

Fulton-Banister, Ltd.
410 Northern Hardware Building
Edmonton, Alberta, Canada

Gabe's Construction Company
2019 North 10th Street
Sheboygan, Wisconsin

H. L. Gentry Construction Company
921 East Michigan
Jackson, Michigan

George Consolidated
7225 Culmore Street
Houston, Texas

Golightly Construction Corp.
6450 Liberty Road
P. O. Box 15243
Houston, Texas
Telephone: ORchard 2-0561
W. L. Golightly, President

Gragg Canada, Ltd.
295 Kipling Avenue South
Box 26
Toronto 14, Ontario, Canada
Telephone: CLifford 9-9211
C. H. Gragg, President

Z. J. Graham
732 North Grand
Box 1203
Amarillo, Texas

Gray-Morrison Contractors, Inc.
Box 3055
Austin 13, Texas
Telephone: 7-8503
Jack S. Gray, President

Gregg Construction Company
Box 886
Longview, Texas

G. G. Griffis, Inc.
4450 East Admiral Place
Tulsa, Oklahoma

Groninger & King
Box 1381
Pampa, Texas

The Hallen Company, Inc.
45-30 37th Street
Long Island City 1, New York

Hallmac Construction Company
3701 Buffalo Drive
Houston 19, Texas
Telephone: JAckson 2-2445
James W. Hall, President

Hardy, Williamson & Arnold Pipe Line Contractors
Box 2105
Wichita Falls, Texas

A. C. Holder Construction Company, Inc.
1712 East Fifth Street
Box 3297
Whittier Station
Tulsa, Oklahoma

Hood Construction Company
3002 East Century Blvd.
Box 112
Lynwood, California

Houston Contracting Company
2707 Ferndale Place
Houston 6, Texas

Hupp, Ltd.
606 Northern Hardware Building
Edmonton, Alberta, Canada

Jayhawk Construction Company, Inc.
Box 419
Great Bend, Kansas

KLW Pipe Line Construction Company
607 State Life Building
Indianapolis 4, Indiana
A. A. Kalo, General Manager

Knupp Construction Company, Inc.
Box 152
Great Bend, Kansas
Telephone: 3528
H. V. Knupp, President

The Kuljian Corporation
1200 North Broad Street
Philadelphia 21, Pennsylvania

Lone Star Construction Company
Box 55
Winnie, Texas

Lone Star Constructors
10301 Shady Trail
Box 13167
Dallas 20, Texas
Telephone: FLeetwood 7-2833
Paul R. Halbert, Partner
N. K. McFarland, Partner

W. M. Lyles Company
Box 495
Avenal, California
Telephone: AVenal 222
W. M. Lyles, President

Macco Corporation
14409 South Paramount Blvd.
Paramount, California

Majestic Contractors, Ltd.
408 Royal Trust Building
Edmonton, Alberta, Canada

Mannix, Ltd.
332 Seventh Avenue West
Calgary, Alberta, Canada
Telephone: Calgary 6-7361
F. C. Mannix, President

Mary Construction Company, Inc.
Box 423
Cape Girardeau, Missouri

Massey Pipe Line Construction Company
Box 2099
Corpus Christi, Texas

McVean and Barlow
Box 151
Odessa, Texas

Midcontinent Construction Company
Box 484
Wichita, Kansas

M. G. M. Construction Company
Box 1056
Concord, California

Mid-States Construction Company
Box 417
Mt. Vernon, Illinois
Telephone: 5245
O. A. Holdren, President

The Petroleum Engineer's 1955-56 Pipe Line Contractors Directory . . .

Midwestern Constructors, Inc.
105 North Boulder
Tulsa 3, Oklahoma

Midwestern Contractors, Inc.
130 West Liberty Drive
Wheaton, Illinois
Telephone: WHeaton 8-3420
A. T. Everham, President

Mitchell Construction Company
301 West 53rd Street North
Wichita, Kansas
Telephone: TEmple 8-6141
Vernon E. Mitchell, President

Modern Welding Company
1500 East Twelfth Street
Box 528
Owensboro, Kentucky
Telephone: MUrray 3-5323
J. H. Mosby, Jr., Executive Vice President

Morrison Constructors
Box 3206
Austin 13, Texas
Telephone: 7-8503
J. S. Gray, President

Morrison Construction Company, Inc.
1834 Summer Street
Hammond, Indiana

M-R Company
Box 484
Wichita, Kansas

H. H. Null Pipe Line Contractors
215 Lockwood Drive
Houston 11, Texas

Ohio Pipe Line Construction Company, Inc.
607 State Life Building
Indianapolis 4, Indiana
Albert A. Kalo, President

Oklahoma Pipe Line Constructors
6612 Harry Hines Blvd.
Box 13327
Dallas, Texas

Oman Construction Company
Box 146
Nashville, Tennessee

Pacific Pipeline Construction Company
1632 South Greenwood Avenue
Montebello, California

Panama Williams Corp.
1418 Melrose Building
Houston, Texas
Telephone: CApital 5-3507
Maurice Williams, President

Pipe Line Construction & Drilling Company
Box 165
301 Market Street
Lemoyne, Pennsylvania

Pipeline Service Company
540 West Strother
Box 32
Seminole, Oklahoma

Pitts & Bryant Company, Inc.
Box 432
Clarksville, Arkansas
Telephone: 795
R. E. Pitts, Vice President and General Manager

H. C. Price Company
Union National Bank Building
Box 1111
Bartlesville, Oklahoma
John M. Thomas, Vice President

River Construction Corp.
6100 Camp Bowie
Box 9127
Fort Worth, Texas

Alex Robertson Company
14433 South Paramount Blvd.
Box 757
Paramount, California

C. L. Rogers Construction Company, Inc.
1114 City National Building
Box 1706
Wichita Falls, Texas

Ross-Powers Construction Company
1131 North Thirtieth Street
Box 2038
Billings, Montana
Telephone: 9-2038
Grady T. Ross, Partner

N. A. Saigh Company, Inc.
Suite 531, Majestic Building
San Antonio 5, Texas
Telephone: CApital 5-2933
N. A. Saigh, President

Shamrock Construction Company
307 Mutual Building
Lansing, Michigan

F. E. Shaw, Ltd.
530 South Vidal Street
Sarnia, Ontario, Canada
Telephone: Dlgby 4-2416
F. E. Shaw, President

Sheehan Pipe Line Construction Company
514 National Bank of Tulsa Bldg.
Tulsa, Oklahoma
R. D. Sheehan, Managing Partner

Sheppard-Geiger Construction Company
Box 2098
Corpus Christi, Texas

F. L. Showalter, Inc.
Box 623
Lynchburg, Virginia

Slade & McElroy, Inc.
2105 25th Avenue, Box 255
Gulfport, Mississippi

Smith Contracting Corp.
R.F.D. No. 6, Box 211
Fort Worth, Texas
Telephone: Vlnewood 2113
O. R. Smith, President

Somerville Construction Company
6648 Fulton Road
Ada, Michigan

Southwest Pipeline Constructors, Inc.
Box 12327
Houston, Texas

Standard Contracting Company, Inc.
Box 14537
6000 Chocolate Bayou
Houston 21, Texas

Trojan Construction Company, Inc.
Suite 200, 1416 North Robinson
Oklahoma City 3, Oklahoma
Telephone: CEntral 2-7696
Felix M. Johnson, President

George Tucker Pipe Line Construction
Box 1987
Odessa, Texas

Vaughn & Taylor Construction Company, Inc.
2103 North Grant
Box 2624
Odessa, Texas
D. D. Vaughn, President

Ventura Pipeline Construction Company
899 North Olive Street
Box 1252
Ventura, California

Virginia Pipe Line Construction Corporation
Box 156
Hampton, Virginia

L. E. Webb Construction Company, Inc.
Box 705
Santa Maria, California

Western Pipe Line Constructors
Box 798
Austin, Texas

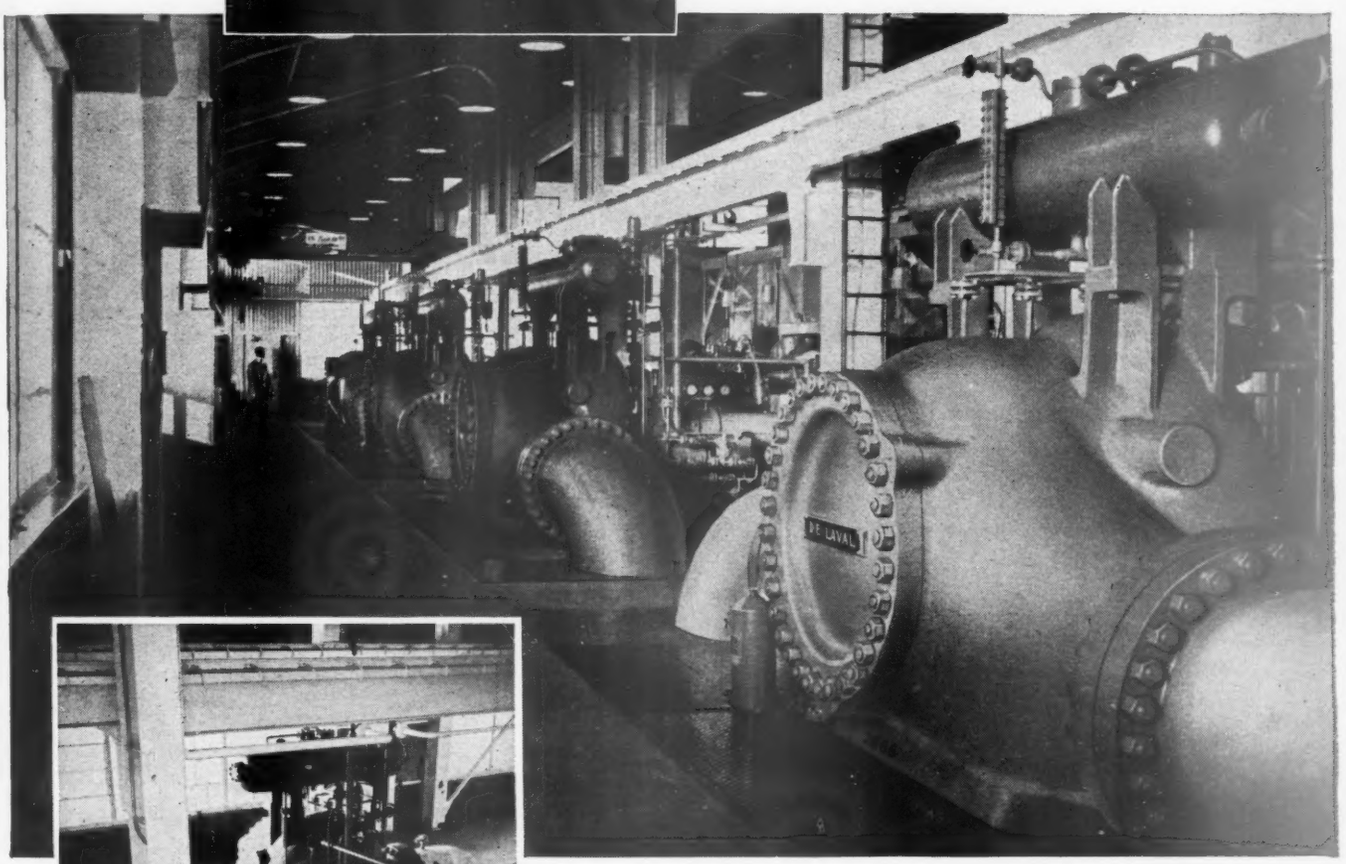
Williams-Austin Company
3322 Grant Building
Pittsburgh 19, Pennsylvania
Telephone: ATlantic 1-8170
G. A. Manuel, President

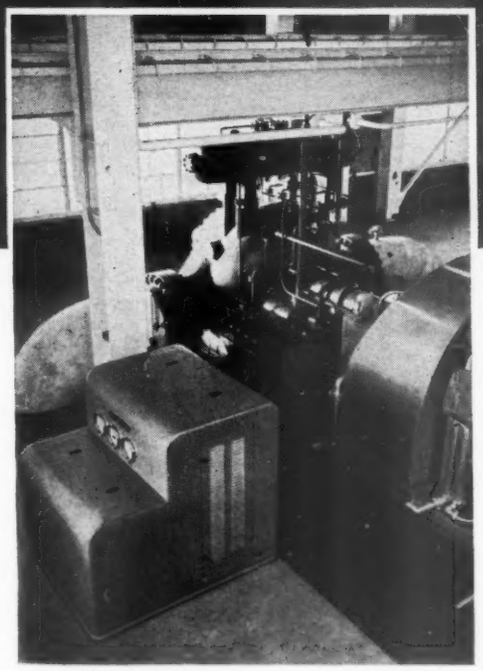
Williams Brothers Company
326 National Bank of Tulsa Bldg.
Tulsa 3, Oklahoma

C. E. Wilson Construction Company
1401 Fairfax Trafficway
Kansas City 15, Kansas
Telephone: FAirfax 6287
C. E. Wilson, Owner

H. B. Zachry Company
Box 2570
San Antonio 6, Texas

FOUR DE LAVAL CENTRIFUGAL COMPRESSORS *in Tescott, Kansas station of Northern Natural Gas*





For easy installation, De Laval pipeline compressors are designed in two packages: (1) The machine plus the emergency seal tank, (2) The auxiliary console which contains the filters, pumps, coolers and other accessories.

Here's more proof of the efficiency and dependability of De Laval centrifugal compressors for high pressure gas transmission. This Tescott, Kansas station of the Northern Natural Gas Co. has four De Laval centrifugal compressors in series.

The station flow is 930 M²SCFD, station inlet pressure 477 psig and discharge pressure 745 psig. *By changing the impeller and a few minor parts, these units can handle 1,100 to 1,200 M²SCFD.* Three identical De Laval compressors are on the job in the Macksville, Kansas station of Northern Natural.

De Laval centrifugal compressors offer important engineering features. • Pressure contact shaft seal eliminates gas leakage. • Construction is heavy and rigid throughout. • Units have high load carrying capacity. De Laval units, totaling more than 200,000 hp, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
869 Nottingham Way, Trenton 2, New Jersey

Pipe gang works up-hill on western end of the Hebron-Greenwich line in western Pennsylvania.

The barge, apparently also used for oil transport, rested on the bottom near the end of the pier. It was sealed, pumped out and raised, towed to sea and sunk.

"Suburban Pipelining"

The problem in Westchester County was one caused by a lack of open country for pipe line right-of-way. Suburban development made it necessary to follow county-owned land wherever possible so as to forestall any outsized disturbance of private property.

Consequently, one section of the line, in and near White Plains, New York, will rest in a ditch dug down the middle of one traffic lane of the Bronx River Parkway, which links Westchester County with New York City. In the same area, the right-of-way crosses the Bronx River five times in 1½-mile stretch.

Also in that area, the contractor had to keep a close watch for and lay plans for circumventing a veritable grid of utility lines.

Other heavily-traveled thoroughfares lying along the line's route in Westchester County include the Saw Mill River, Central Westchester and Hutchinson River Parkways, and Westchester Avenue.

Right-of-way was acquired from the Westchester County government for this section of the Hebron-Greenwich line. Shown here is section of ditch being dug down middle of a traffic line of busy Bronx River Parkway, main artery to New York City.

The contractors for western portions of the Hebron-Greenwich line completed their work by the end of July. H. C. Price Company laid 50 miles, starting from Coudersport. Another 109 miles, taking up where the Price company left off, were built by the Oklahoma Construction Company. Oklahoma's work also included construction of the Susquehanna River crossing, which was completed in July.

The August 18 cloudburst and subsequent flood in Pennsylvania and New Jersey plagued the Bechtel Corporation and Pentzien, Inc., contractors for the remainder of the line. Pentzien, Inc., contractor for the Delaware River crossing, was just about ready to pull pipe when the rains came, and the Bechtel Corporation lost some of its ditch in the flood.

Pipe line district headquarters being set up along the line are near Troy, Pennsylvania, near Nicholson, Pennsylvania, and near Ramsey, New Jersey. A pipe line warehouse, office and radio tower will be maintained at each location.

New Coastal Line

The 370-mile Agua Dulce-Kinder pipe line now under construction will run parallel to and near the Gulf of Mexico coastline, cutting across a coastal sector that has significant supplies of natural gas, from the standpoint of both onshore and offshore operations.

A substitute in part for previously-authorized but never built loops along the main system between Agua Dulce and Natchitoches, Louisiana, the new 30-in. line will tie in at Kinder with a 30-in. line that TGT built in 1954 from Kinder to Portland, Tennessee.

The Agua Dulce-Kinder line's route entails nine major water crossings. The Lavaca Bay crossing, about 29,000 ft, will be the longest submerged crossing ever made by a TGT main line. The other major crossings, all to be submerged also, will be constructed at the Guadalupe, Colorado, Brazos, Trinity, Neches and Sabine Rivers; the Houston Ship Channel, which is flanked by San Jacinto and Tabbs Bays, and Cedar Bayou, near Baytown, Texas.

Across the Ship Channel, route of ocean liners from the Gulf of Mexico to the Port of Houston, a ditch depth of 50 ft below the surface of the water, or 16 ft beneath the channel bottom, will be necessary.

Contractors for the Agua Dulce-Kinder line are Morrison Constructors, Inc., Williams Bros., Houston Contracting Company, H. C. Price Com-

pany, Western Constructors, N. A. Saigh Company, Panama-Williams Company, and Associated Pipe Line Constructors, Inc.

Pecan Island Lateral

TGT's major gathering line project of the year was the 58-mile, 20-in. pipe line laid from Kinder southward to Pecan Island, near the onshore terminal of a submarine pipe line from the Pure Oil Company's Rollover Field in the Gulf of Mexico.

For about half its length, the Pecan Island line had to be laid under water. Houston Contracting Company used barges during construction wherever possible, while at other points sections of pipe were literally shoved along water-filled ditches from islands built along the marshy right-of-way.

Where shoving was necessary, the cement-coated pipe was four-jointed at the shove point and four empty 55-gal oil drums were fastened, with metal box straps, to each 40-ft joint. Then the 160-ft long sections were welded into the line and launched by winch tractors. The barrels provided the buoyancy needed to float the line during construction. Afterwards, workmen in boats cut the drums loose and the pipe line, weighted by its coating of cement, sank into its water-filled trench. The longest section of the pipe line laid in this manner was 31,000 ft.

Where barges were used, four of them were coupled together, providing six work stations — two for lineup, stringer bead and hot pass, two for welding and two for coating. Two single joints of pipe were added at a time. The pipe was supported on the barges by rubber-clad tracks made from war surplus half-tracks.

Other Facilities

The loop lines built near McConnellsville, Ohio, and Mercer, Pennsylvania, by H. C. Price Company, gave the company two 26-in. lines from the Ohio River to Mercer.

Completion of a 24-in. line from the Harrison Storage Field to the Coudersport, Pennsylvania, compressor station will enable the company to develop its third storage facility. The other two are the nearby Hebron field at Coudersport and the Colden Field near Buffalo.

The storage program, operated in conjunction with the 1000-mile "loop" afforded by completion of the Hebron-Greenwich pipe line, will provide TGT's customers with extremely dependable and flexible service.

Plans for the new Morehead, Kentucky, compressor station called for the installation of two 6700-hp gas turbines, while the new station at Isola, Mississippi, will operate with five 1100-hp engine-reciprocating units.

Concrete-coated pipe sections were shoved into the water-filled ditches on the Pecan Island gathering line. Barrels, tied to the line for added buoyancy during the shoving operation, were later cut loose and line sank slowly to bottom of swampy ditch.

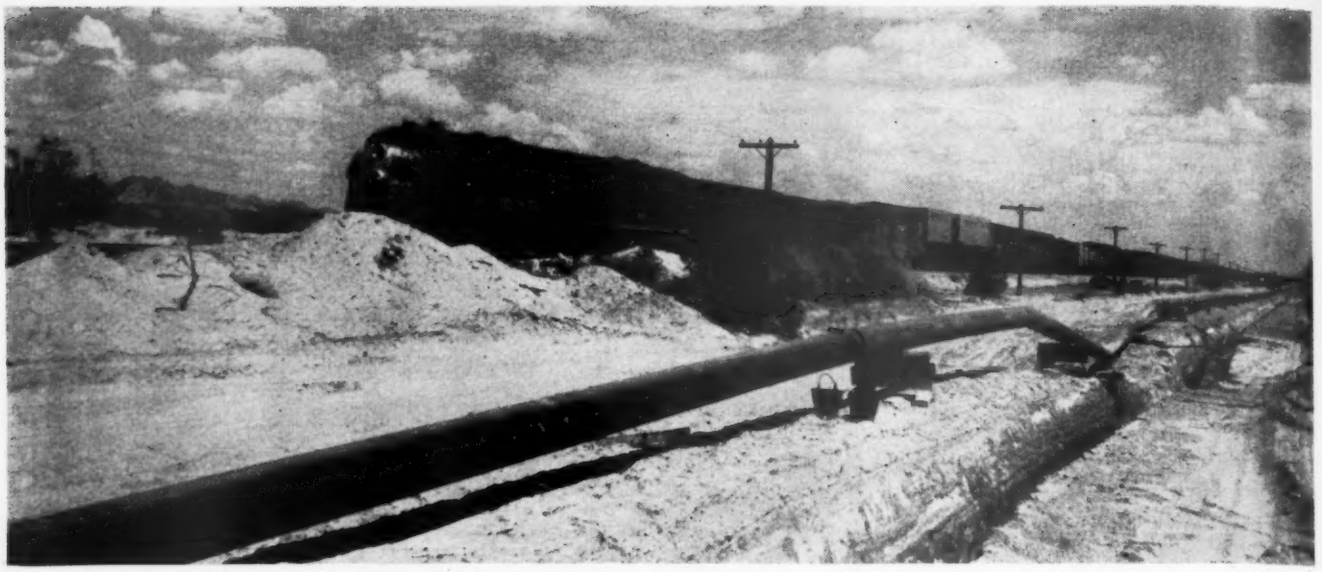
Three units of 2000-hp each are being added at Winchester, Kentucky, and two similar units are going in at Albany, Ohio.

The Coudersport station was being expanded by 6600-hp (five 1320-hp units) and the enlargement of the station at Hamburg, New York, involved the installation of two 1000-hp engines.

Completion of the 1955 construction program will mark a two-year period of impressive growth for TGT. During 1954, the company laid the 576-mile, 30-in. pipeline—from Kinder, Louisiana, to Portland, Tennessee—to which the new Agua Dulce-Kinder line will be tied; built 130 miles of 26-in. loop line in Ohio, and constructed a 45-mile line from near Buffalo, New York, to the Niagara River, through which service to Toronto, Canada, was initiated. A new compressor station was installed at Coudersport and two other stations were enlarged. * * *

Road crossings, though no problem for pipeliners, were numerous on some sections of the Hebron-Greenwich line. This crossing for the 24-in. line was in Pennsylvania.

XUM



Southern Pacific freight train passes the company's new products pipe line under construction on adjacent right-of-way.

Construction Report

Texas-California Products Line Nears Completion

J. B. Stumm
West Coast Editor

New 847-mile, $30,000,000 products system built by railroad company on its own right-of-way between El Paso and Los Angeles to be ready in December

THE first common-carrier products pipe line ever to be constructed by a railroad on its own right-of-way in this country is making on-schedule progress as it wends its way through the torrid desert country lying between Los Angeles, California, and El Paso, Texas.

Southern Pacific Pipe Lines, Inc., a subsidiary of Southern Pacific Company, is building the unique 847-mile pipe line system to carry petroleum products—regular, premium, and aviation gasoline; diesel oil, and jet fuel—from refineries in Los Angeles and El Paso to the fast growing markets in the populated areas of Arizona.

There are presently no refineries in Arizona, and the Southern Pacific Company, with its inherent advantage of its own private right-of-way, will be in a position to serve all companies distributing petroleum products in those parts of Arizona contiguous to Southern Pacific rail lines. Because of transportation rate savings, as pointed out by a California oil company executive, the line will permit his company to reduce the price of gasoline by about 1½ cents per gallon for Phoenix and Tucson, with corresponding reductions elsewhere in the areas to be served by the line. Similar price reductions in other products carried by the line will also be affected.

Route of the Line

The pipe line generally follows the railroad right-of-way from Los Angeles to Phoenix and Tucson, serving the important intermediate areas of Colton, the Imperial Valley and Yuma. The route followed between Tucson and El Paso is the shortest practical one, using the railroad right-of-way where it is economically practical.

Exact route of the pipe line, as shown on the accompanying strip map, is from Watson (Los Angeles) to Colton, then to Yuma and Phoenix, via Hassayampa. From El Paso to Phoenix, the line passes through Lordsburg, New Mexico, and Tucson.

The pipe line will make six major river and canal crossings by suspension spans. They include: The Rio Grande River, 280 ft; the San Pedro River, 1020 ft; the Colorado River, 840 ft; the All-American Canal 440 ft; the Yuma Main Canal, 240 ft, and the Coachella Canal, 280 ft.

Size and Capacity of Line

The line will consist of a 16-in. section from Watson to Colton, 62 miles, with a capacity of 42,000 bbl per day at 600 psi; a 12-in. line from Colton to Phoenix, 356 miles, with a capacity of 36,000 bbl per day at 1350 psi, and an 8-in. line from El Paso to Phoenix, 424 miles, with a capacity of 13,600 bbl per day at 1320 psi.

There will be three pump stations on

Map shows route of line and pipe diameters on the 847-mile system.

the line, at Watson, Colton, and El Paso. The Watson Pump Station will consist of three four-stage, 4 by 6 by 11 horizontal-shaft, split-case, double-volute centrifugal pumps driven by three 300-hp, 2300 v, 3600-rpm synchronous speed induction motors.

Colton Pump Station will consist of three five-stage, 6 by 8 by 11 horizontal-shaft, split-case, double-volute centrifugal pumps driven by three 900-hp, 2300 v 3600-rpm synchronous speed induction motors.

El Paso Pump Station will have two five-stage, 3 by 4 by 10 horizontal-shaft, split-case, double volute centrifugal pumps driven by two 300-hp, 2300 v, 3600-rpm synchronous speed induction motors.

Construction Progress

With final approval of the project by the board of directors of the Southern Pacific Company late in February, initial planning and design of the pipe line was begun by Engineering Management, Inc., in Los Angeles, on March 1, 1955, under the direction of D. L. Roberts, vice president and project manager. In order for the system to be completed and in operation by December 31, 1955, actual line construction was divided into eight schedules, awarding separate contracts on each.

Construction Data

All pipe for the entire line is being supplied by Kaiser Steel Corporation of Fontana and Basalt, California, and National Tube Company, Lorain, Ohio.

Pipe wall thickness varies from 7/32-in. to ⅜-in. The 16-in. and 8-in pipe is 5LX4200 and the 12-in. is 5LX4600. All welds are checked by X-ray and gate valves are being installed at approximately 20-mile intervals with others at key points. Hydrostatic testing of the line is to 90 per cent of yield.

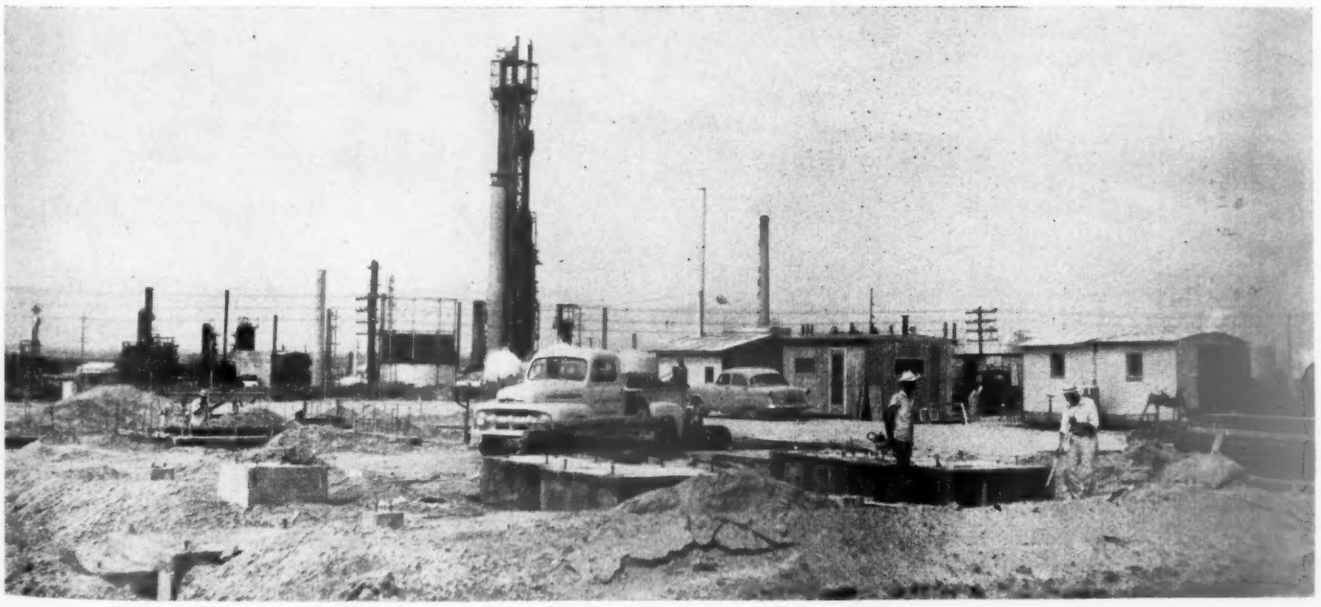
Stringing of pipe is being handled from unloading points by trucks, and the pipe is welded and wrapped as laid, except for the 16-in. pipe, which is being coated and stored at Watson. The 12-in. and 8-in. pipe is asphalt coated and glass fiber inner wrapped. The outer wrap on the 12-in. is glass fiber and the outer on the 8-in. is felt. The 16-in. pipe is all Somastic coated.

Soil conditions along the route vary from loam to sand with some caliche and about 2 per cent rock. The terrain is mostly desert with some mountainous. Generally, the pipe is being cradled into the ditch with slack loops at 400 to 600 ft. Normal cover on the pipe is 30-in. with extra depth in certain agricultural areas and adjacent to railroad tracks.

Take-Off Points

Take-off terminals will be at Colton and Niland, California, on the western line and at Tucson, Arizona, on the eastern line, with the terminal for both lines at Phoenix. Phoenix terminal fa-

Foundations under construction near El Paso for the pumping station at east end of the new 847-mile line.



New type coating and wrapping machine — a hydraulic, self-cradling unit powered by engine on dope kettle followed by a recirculating water-spray ring-type cooler — received its maiden run on the Macco-Robertson spread.

Crew attaches hose lines to temporarily sealed pipe end for an intermediate air test near Yuma, Arizona. Line will later be hydrostatically tested to 90 per cent of yield point.

cilities are to be constructed on approximately 60 of 112 acres of newly acquired property fronting on Van Buren Street and 51st Avenue. Purchased by Southern Pacific Company, the land is in Maricopa County territory of SP's main rail line into Phoenix from the west. Tank farms and receiving points for as many as eight shippers will be established on the 60 acres, the balance of the property being held for future industrial development.

Approximately 40 acres of land near Davis-Monthan Air Base have been optioned for the Tucson terminal.

Officers of Southern Pacific Pipe Lines, Inc., the Southern Pacific Company subsidiary that will operate the completed line, are D. J. McGanney, president; E. E. Mayo, vice president, and F. E. Kalbaugh, general manager.

Line Construction.

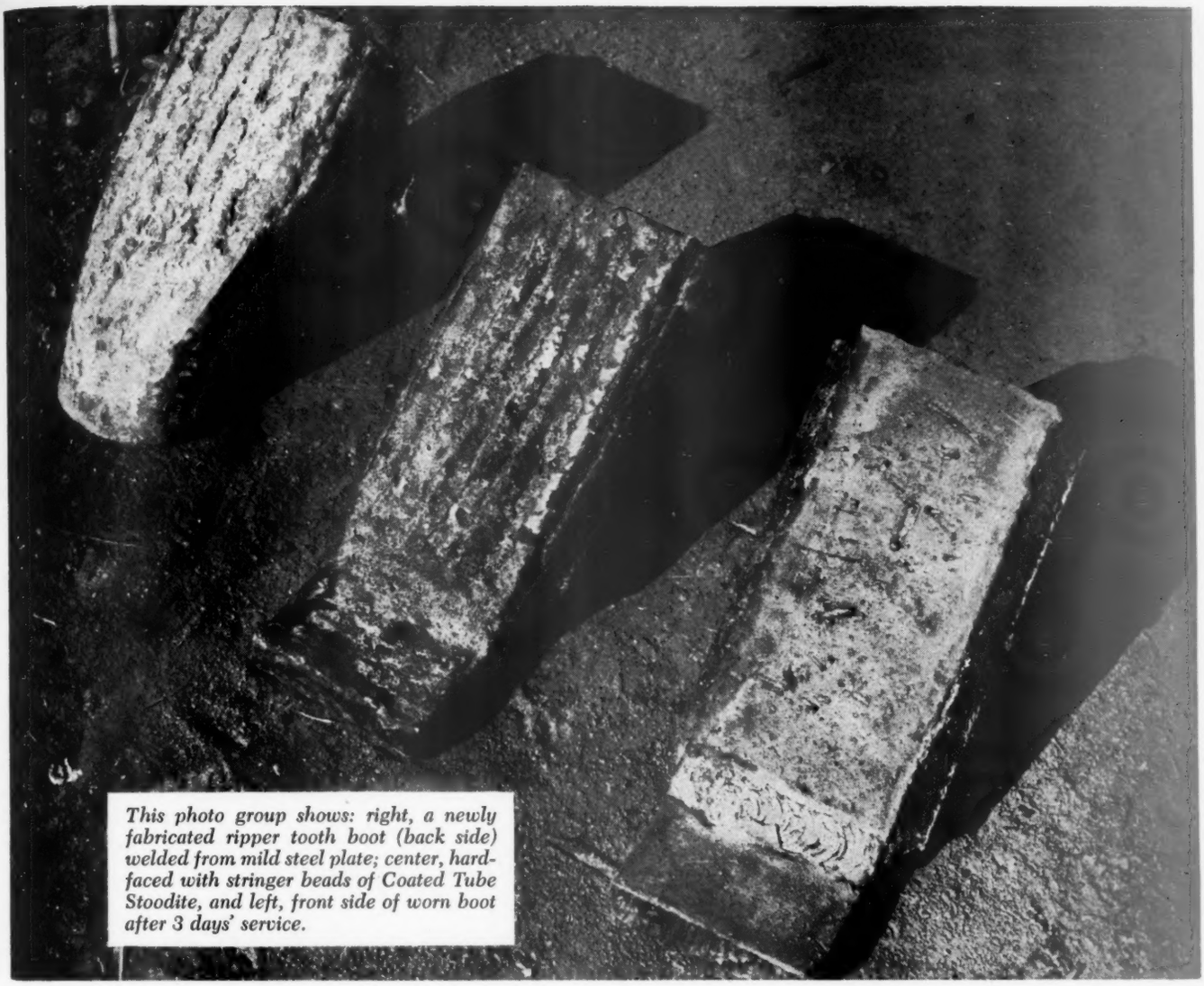
Schedule 1	Lordsburg, New Mexico, to El Paso, Texas — 159 miles of 8 in. pipe.	Morrison-Knudsen Company, Inc., Los Angles, California.
Schedule 2	Lordsburg, New Mexico, to Tucson, Arizona — 144 miles of 8 in. pipe.	R. H. Fulton & Company, Lubbock, Texas.
Schedule 3	Tucson to Hassayampa River, Arizona — 122 miles of 8 in. and 35 miles of 12 in. pipe.	Hood Construction Company, Lynwood, California.
Schedule 4	Yuma, Arizona, to Hassayampa River — 127 miles of 12 in. pipe.	Macco Corporation and Alex Robertson Company, Paramount, California.
Schedule 5 & 6	Yuma, Arizona, to Colton, California — 195 miles of 12 in. pipe.	Conyes Construction Corporation, San Pablo, California.
Schedule 7	Colton, California, to LaHabra, California — 43 miles of 16 in. pipe.	J. E. Young Pipe Line Contractor, Inc., Los Angles, California.
Schedule 8	Watson, California, to LaHabra, California — 19 miles of 16 in. pipe.	Engineers Limited Pipe Line Company, Los Angles, California.

Other Contracts.

El Paso Pump Station	Robert E. McKee General Contractor, Inc., El Paso, Texas.
Colton Pump Station	J. H. Pomeroy & Company, Inc., San Francisco, California.
Watson Pump Station	J. A. McNeil Company, Inc., Alhambra, California.
Rio Grande River and Coachella Canal spans	Associated Pipe Line Contractors, Inc., Houston, Texas.
San Pedro River Span	Ashton Building Company, Tucson, Arizona.
Colorado River, Yuma Main and All-American Canal spans.	Morrison-Knudsen Company, Inc., Los Angles, California.
Tankage	
El Paso, Watson, and Niland terminals	Chicago Bridge & Iron Works.
Phoenix and Tucson terminals	Consolidated Western Steel Division, United States Steel.
Colton terminal	Southwest Welding & Manufacturing Company, Alhambra, California.

Water at Yuma — too much of it in photo at left, caused serious delay at times. Extremely heavy rains, unusual for desert country, deluged area. Pumps are shown here draining a flooded section of ditch. At right is portrayed a common sight in the hot arid country — a trip to the water cooler, welcome relief when the thermometer hit 115 degrees in the vicinity of Yuma.

XUM

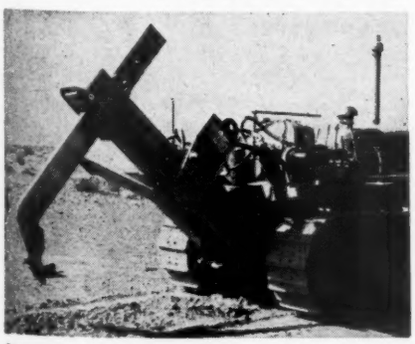


This photo group shows: right, a newly fabricated ripper tooth boot (back side) welded from mild steel plate; center, hard-faced with stringer beads of Coated Tube Stoodite, and left, front side of worn boot after 3 days' service.

HARD-FACED RIPPER TOOTH

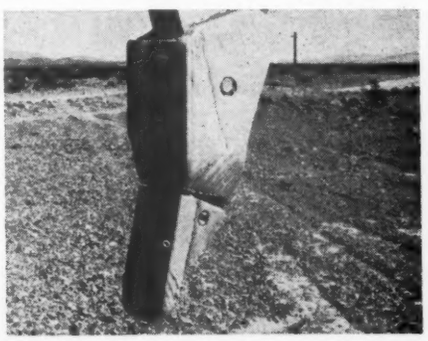
Lasts 1200% Longer on Desert Duty!

Near Ludlow, California, PG&E is spanning the vast Mojave Desert with a gas pipeline. To ease the trenching job a gigantic ripper is towed by a D7 tractor ahead of the ditcher. Its purpose is to break up the hard-packed earth and locate the frequent sub-surface lava flows. This lava is so hard and tightly bonded that explosives must be used to break up the formation.



Depth at which ripper operates is evident by length of standard.

The ripper on this job is designed for easy maintenance; boot type point and adapter are replaceable. The points are fabricated from mild steel plate in the



Close-up shows point attached to tooth adapter. Entire tooth is hard-faced with Coated Tube Stoodite.

division headquarters maintenance shop of the pipeline company handling the job, Engineers Limited Pipeline Co., Bakersfield, California. All four sides are hard-faced with Coated Tube Stoodite before being placed in service.

Working deep in the highly abrasive earth, unprotected boots last only 2 hours. When hard-faced with Coated Tube Stoodite this short life is extended to three full days—an increase of 1200%.

Coated Tube Stoodite is a recent Stoody development for manual application, combining high wear resistance, good impact strength, fast deposition and low cost. Ask your Stoody dealer for details (consult the yellow pages of your phone book) or write direct.

STOODY COMPANY
11955 East Slauson Avenue
Whittier, California

1955-56 Pipe Line Contractors Directory

Here is an up-to-date listing of both general and specialized pipe line contracting companies. Given are the firm names, addresses, telephone numbers, and chief contact in each company, as furnished by the companies themselves. The first three pages are lists of those firms that do general pipe line contracting. Specialized firms are listed on the last two pages.

A. B. C. Construction Company, Inc.
12420 South Bollmfield Avenue
Norwalk, California

E. K. Aldridge & Sons, Inc.
P. O. Box 692
Athens, Ga.

Altgelt Construction Company, Inc.
3502 Lawrence Drive
Box 1402
Corpus Christi, Texas

Anderson Brothers Corp.
Box 8157
Houston 4, Texas
Telephone: JAckson 3-4323
Carl C. Anderson, President

Arey Construction Company
Box 1501
Pampa, Texas

John A. Artukovich Sons, Inc.
16200 South Atlantic Avenue
Paramount, California

Associated Pipe Line Contractors, Inc.
3272 Westheimer
Box 13216
Houston 19, Texas
Telephone: JAckson 4-7561
John M. Gay, Vice President and General Manager

Associated Pipeline, Inc.
509 Mayfair Road
South San Francisco, California

B & B Contracting Company
Box 30
Eldorado, Kansas

B & M Construction Company
1501 Republic Building
Oklahoma City, Oklahoma

Baker Contracting Company, Inc.
Route 4, Box 929
Shreveport, Louisiana

Ray D. Baker Contractor, Inc.
19200 West Eight Mile Road
Detroit 35, Michigan

Banister Construction, Ltd.
409 Northern Hardware Building
Edmonton, Alberta, Canada

Barry Construction Company
4108 Old Spanish Trail
Houston, Texas

C. P. Bartley & Son
Box 616
Tioga, North Dakota
Telephone: 4-2214
C. P. Bartley, Sr., President

Bates & Dungey, Inc.
Sparta, Illinois

Baughman Contracting Company, Inc.
Rt. 1, Box 569
Cumberland, Maryland

Bechtel Corporation
220 Bush Street
San Francisco 4, California

Bills Construction Company
1748 E. 13th Place
Box 644
Tulsa, Oklahoma

Henry Borger & Son, Ltd.
590 Pembina Highway
Winnipeg, Manitoba, Canada

Boyle Construction Company
Sumter, South Carolina

Brodie Construction Company
Box 2064
Amarillo, Texas

Brown & Root, Inc.
4100 Clinton Drive
P. O. Box 3
Houston, Texas
Telephone: FAirfax 3-7121
L. E. Minor, Manager

Buchanan Pipe Line Company, Inc.
Box 1903
Birmingham, Alabama

O. R. Burden Construction Corp.
6702 East 21st Street
Box 5216
Tulsa, Oklahoma
Telephone: TEmple 8-3378
O. R. Burden, President

Canadian Bechtel, Ltd.
44 King Street West
Toronto, Ontario, Canada

Canadian Construction Company, Ltd.
Box 280
Leduc, Alberta, Canada

C. P. Carter Construction Company
Box 928
Duncan, Oklahoma

C & R Constructors, Inc.

C. Hubert Gragg Construction Company
223 Britton Road
Oklahoma City 14, Oklahoma

Colorado & Wyoming Construction Company
Box 211
Loveland, Colorado

Comstock, Ltd.
206 Laird Drive
Comstock Building
Toronto, Ontario, Canada

Conner & Lasater Construction Company
Box 1025
Odessa, Texas
Telephone: 7-0482
Jack A. Conner, President

Consolidated Gas & Service Company
327 LaSalle Street
Chicago 4, Illinois
J. C. Donnelly, President

Construction Service Company
Lincoln Blvd. at Cedar
Box 311
Bound Brook, New Jersey
J. J. Senesy, President

Contracting & Material Company
1235 Dodge Avenue
Evanston, Illinois
Telephone: GR 5-6960
Richard D. Cagney, Vice President

Conyes Construction Corp.
13685 San Pablo Avenue
San Pablo, California

Corbett Contracting Corp.
Ferguson Building
Rawlins, Wyoming

Cumberland Contracting Company, Inc.
Monticello, Kentucky

A. J. Curtis Construction Company
Box 2009
Casper, Wyoming

Mitchell Darby Construction Company
Box 447
Pharr, Texas
Telephone: ST 7-3481
Mitchell Darby, President

B. J. Davis Construction Company
Box 117
Ashland City, Tennessee

George W. Davis Construction Company
1414 N. Eastern
Box 186
Oklahoma City, Oklahoma

Donaldson Construction Company
Dodge Center, Minnesota

Dutton-Williams Brothers, Ltd.
Pacific Building
Calgary, Alberta, Canada
Telephone: 69-2669
M. A. Dutton, President

Eastern Pipe Line Contractors
820 Mercantile Building
Dallas, Texas
Telephone: RIverside 4081

Engineering-Construction Company
402 North Cheyenne
Tulsa, Oklahoma

Engineers Limited Pipeline Company
225 Bush Street (General Office)
San Francisco 4, California
Telephone: GArfield 1-2980

John D. Fahey and Son, Inc.
306 First National Bank & Trust Building
Waynesburg, Pennsylvania

L. E. Farley, Inc.
5247 Buffalo Speedway
Houston, Texas

Ferguson Construction Company
Box 127
Eunice, New Mexico

Fish Pipe Line Construction Company
796 M & M Building
Box 2617
Houston, Texas

C. Wayne Fowler
Box 368
Cotton Valley, Louisiana

George W. Fowler, Contractor
Drake Building
Box 386
Minden, Louisiana

Fulghum Contracting Corporation
Box 1181
Harrisburg, Pennsylvania

R. H. Fulton & Company
Box 1526
Lubbock, Texas

Fulton-Banister, Ltd.
410 Northern Hardware Building
Edmonton, Alberta, Canada

Gabe's Construction Company
2019 North 10th Street
Sheboygan, Wisconsin

H. L. Gentry Construction Company
921 East Michigan
Jackson, Michigan

George Consolidated
7225 Culmore Street
Houston, Texas

Golightly Construction Corp.
6450 Liberty Road
P. O. Box 15243
Houston, Texas
Telephone: ORchard 2-0561
W. L. Golightly, President

Gragg Canada, Ltd.
295 Kipling Avenue South
Box 26
Toronto 14, Ontario, Canada
Telephone: CLifford 9-9211
C. H. Gragg, President

Z. J. Graham
732 North Grand
Box 1203
Amarillo, Texas

Gray-Morrison Contractors, Inc.
Box 3055
Austin 13, Texas
Telephone: 7-8503
Jack S. Gray, President

Gregg Construction Company
Box 886
Longview, Texas

G. G. Griffis, Inc.
4450 East Admiral Place
Tulsa, Oklahoma

Groninger & King
Box 1381
Pampa, Texas

The Hallen Company, Inc.
45-30 37th Street
Long Island City 1, New York

Hallmac Construction Company
3701 Buffalo Drive
Houston 19, Texas
Telephone: JAckson 2-2445
James W. Hall, President

Hardy, Williamson & Arnold Pipe Line Contractors
Box 2105
Wichita Falls, Texas

A. C. Holder Construction Company, Inc.
1712 East Fifth Street
Box 3297
Whittier Station
Tulsa, Oklahoma

Hood Construction Company
3002 East Century Blvd.
Box 112
Lynwood, California

Houston Contracting Company
2707 Ferndale Place
Houston 6, Texas

Hupp, Ltd.
606 Northern Hardware Building
Edmonton, Alberta, Canada

Jayhawk Construction Company, Inc.
Box 419
Great Bend, Kansas

KLW Pipe Line Construction Company
607 State Life Building
Indianapolis 4, Indiana
A. A. Kalo, General Manager

Knupp Construction Company, Inc.
Box 152
Great Bend, Kansas
Telephone: 3528
H. V. Knupp, President

The Kuljian Corporation
1200 North Broad Street
Philadelphia 21, Pennsylvania

Lone Star Construction Company
Box 55
Winnie, Texas

Lone Star Constructors
10301 Shady Trail
Box 13167
Dallas 20, Texas
Telephone: FLeetwood 7-2833
Paul R. Halbert, Partner
N. K. McFarland, Partner

W. M. Lyles Company
Box 495
Avenal, California
Telephone: AVenal 222
W. M. Lyles, President

Macco Corporation
14409 South Paramount Blvd.
Paramount, California

Majestic Contractors, Ltd.
408 Royal Trust Building
Edmonton, Alberta, Canada

Mannix, Ltd.
332 Seventh Avenue West
Calgary, Alberta, Canada
Telephone: Calgary 6-7361
F. C. Mannix, President

Mary Construction Company, Inc.
Box 423
Cape Girardeau, Missouri

Massey Pipe Line Construction Company
Box 2099
Corpus Christi, Texas

McVean and Barlow
Box 151
Odessa, Texas

Midcontinent Construction Company
Box 484
Wichita, Kansas

M. G. M. Construction Company
Box 1056
Concord, California

Mid-States Construction Company
Box 417
Mt. Vernon, Illinois
Telephone: 5245
O. A. Holdren, President

Midwestern Constructors, Inc.
105 North Boulder
Tulsa 3, Oklahoma

Midwestern Contractors, Inc.
130 West Liberty Drive
Wheaton, Illinois
Telephone: WHeaton 8-3420
A. T. Everham, President

Mitchell Construction Company
301 West 53rd Street North
Wichita, Kansas
Telephone: TEmple 8-6141
Vernon E. Mitchell, President

Modern Welding Company
1500 East Twelfth Street
Box 528
Owensboro, Kentucky
Telephone: MUrray 3-5323
J. H. Mosby, Jr., Executive Vice President

Morrison Constructors
Box 3206
Austin 13, Texas
Telephone: 7-8503
J. S. Gray, President

Morrison Construction Company, Inc.
1834 Summer Street
Hammond, Indiana

M-R Company
Box 484
Wichita, Kansas

H. H. Null Pipe Line Contractors
215 Lockwood Drive
Houston 11, Texas

Ohio Pipe Line Construction Company, Inc.
607 State Life Building
Indianapolis 4, Indiana
Albert A. Kalo, President

Oklahoma Pipe Line Constructors
6612 Harry Hines Blvd.
Box 13327
Dallas, Texas

Oman Construction Company
Box 146
Nashville, Tennessee

Pacific Pipeline Construction Company
1632 South Greenwood Avenue
Montebello, California

Panama Williams Corp.
1418 Melrose Building
Houston, Texas
Telephone: CApital 5-3507
Maurice Williams, President

Pipe Line Construction & Drilling Company
Box 165
301 Market Street
Lemoyne, Pennsylvania

Pipeline Service Company
540 West Strother
Box 32
Seminole, Oklahoma

Pitts & Bryant Company, Inc.
Box 432
Clarksville, Arkansas
Telephone: 795
R. E. Pitts, Vice President and General Manager

H. C. Price Company
Union National Bank Building
Box 1111
Bartlesville, Oklahoma
John M. Thomas, Vice President

River Construction Corp.
6100 Camp Bowie
Box 9127
Fort Worth, Texas

Alex Robertson Company
14433 South Paramount Blvd.
Box 757
Paramount, California

C. L. Rogers Construction Company, Inc.
1114 City National Building
Box 1706
Wichita Falls, Texas

Ross-Powers Construction Company
1131 North Thirtieth Street
Box 2038
Billings, Montana
Telephone: 9-2038
Grady T. Ross, Partner

N. A. Saigh Company, Inc.
Suite 531, Majestic Building
San Antonio 5, Texas
Telephone: CApital 5-2933
N. A. Saigh, President

Shamrock Construction Company
307 Mutual Building
Lansing, Michigan

F. E. Shaw, Ltd.
530 South Vidal Street
Sarnia, Ontario, Canada
Telephone: Digby 4-2416
F. E. Shaw, President

Sheehan Pipe Line Construction Company
514 National Bank of Tulsa Bldg.
Tulsa, Oklahoma
R. D. Sheehan, Managing Partner

Sheppard-Geiger Construction Company
Box 2098
Corpus Christi, Texas

F. L. Showalter, Inc.
Box 623
Lynchburg, Virginia

Slade & McElroy, Inc.
2105 25th Avenue, Box 255
Gulfport, Mississippi

Smith Contracting Corp.
R.F.D. No. 6, Box 211
Fort Worth, Texas
Telephone: Vinewood 2113
O. R. Smith, President

Somerville Construction Company
6648 Fulton Road
Ada, Michigan

Southwest Pipeline Constructors, Inc.
Box 12327
Houston, Texas

Standard Contracting Company, Inc.
Box 14537
6000 Chocolate Bayou
Houston 21, Texas

Trojan Construction Company, Inc.
Suite 200, 1416 North Robinson
Oklahoma City 3, Oklahoma
Telephone: CEntral 2-7696
Felix M. Johnson, President

George Tucker Pipe Line Construction
Box 1987
Odessa, Texas

Vaughn & Taylor Construction Company, Inc.
2103 North Grant
Box 2624
Odessa, Texas
D. D. Vaughn, President

Ventura Pipeline Construction Company
899 North Olive Street
Box 1252
Ventura, California

Virginia Pipe Line Construction Corporation
Box 156
Hampton, Virginia

L. E. Webb Construction Company, Inc.
Box 705
Santa Maria, California

Western Pipe Line Constructors
Box 798
Austin, Texas

Williams-Austin Company
3322 Grant Building
Pittsburgh 19, Pennsylvania
Telephone: ATlantic 1-8170
G. A. Manuel, President

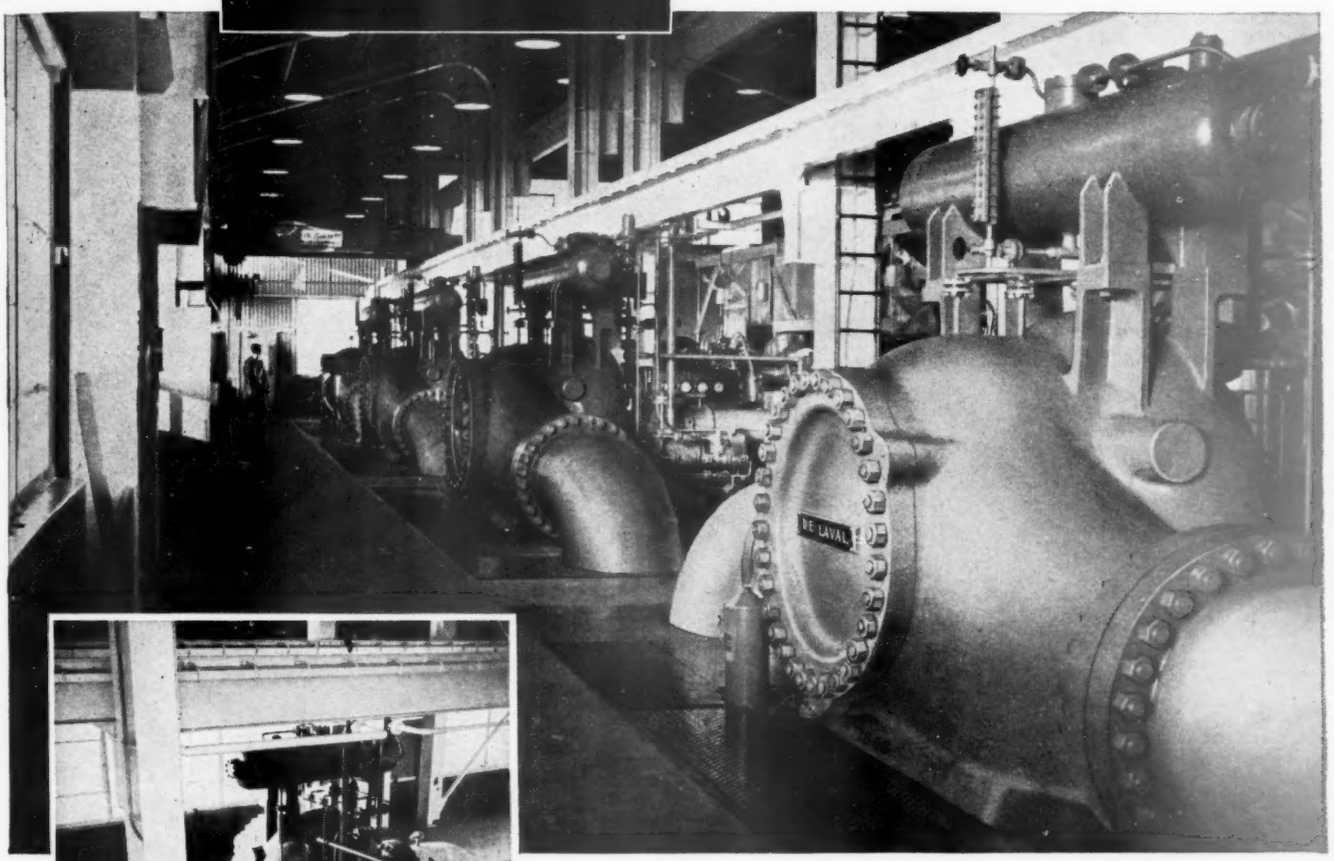
Williams Brothers Company
326 National Bank of Tulsa Bldg.
Tulsa 3, Oklahoma

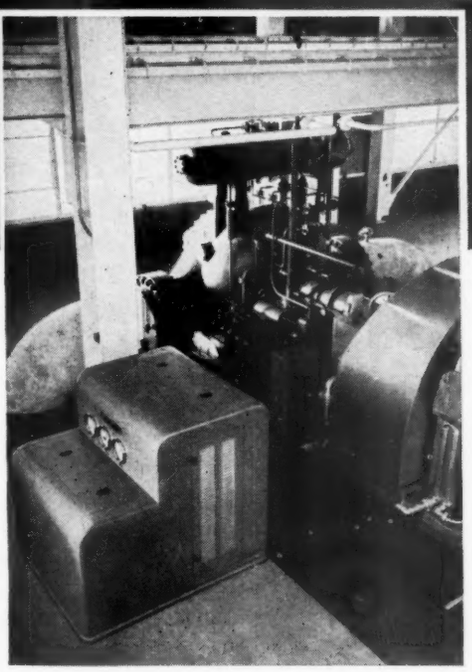
C. E. Wilson Construction Company
1401 Fairfax Trafficway
Kansas City 15, Kansas
Telephone: FAirfax 6287
C. E. Wilson, Owner

H. B. Zachry Company
Box 2570
San Antonio 6, Texas

XUM

FOUR DE LAVAL CENTRIFUGAL COMPRESSORS *in Tescott, Kansas station of Northern Natural Gas*





For easy installation, De Laval pipeline compressors are designed in two packages: (1) The machine plus the emergency seal tank, (2) The auxiliary console which contains the filters, pumps, coolers and other accessories.

Here's more proof of the efficiency and dependability of De Laval centrifugal compressors for high pressure gas transmission. This Tescott, Kansas station of the Northern Natural Gas Co. has four De Laval centrifugal compressors in series.

The station flow is 930 M²SCFD, station inlet pressure 477 psig and discharge pressure 745 psig. *By changing the impeller and a few minor parts, these units can handle 1,100 to 1,200 M²SCFD.* Three identical De Laval compressors are on the job in the Macksville, Kansas station of Northern Natural.

De Laval centrifugal compressors offer important engineering features. • Pressure contact shaft seal eliminates gas leakage. • Construction is heavy and rigid throughout. • Units have high load carrying capacity. De Laval units, totaling more than 200,000 hp, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
869 Nottingham Way, Trenton 2, New Jersey

DL808J

To obtain more information on products advertised see page E-51

Listed on this and the following page are the names, addresses, and chief contact of those firms doing specialized contract services such as coating and wrapping, river crossings, marine pipe line construction, X-ray services, etc.

SPECIALIZED PIPE LINE CONTRACTORS AND SERVICES

Abrams Aerial Survey Corporation
606 East Shiawassee
Lansing 1, Michigan
John C. Bayless, Oil Industry Mgr.
Aerial Surveys

Aero Service Corporation
1401 South Detroit
Tulsa, Oklahoma
Aerial Surveys, Mid-continent area

American Dewatering Corporation
140 Cedar Street
New York City, New York
S. P. Edgar, General Supt.
River Crossing Dewatering

American Pipe Coating Contractors, Inc.
Box 196
Lake Charles, Louisiana
Telephone: HE 9-4027
Lewis A. Wheeler, Jr., President
Coating and Wrapping
Pipe Reconditioning

Atlantic Gulf & Pacific Company
15 Park Row
New York 38, New York
Marine Dredging

C. F. Bean Contractor
Box 335
Plaquemine, Louisiana
C. F. Bean, President
Marine Dredging

W. A. Beiggs Bitumen Company
3303 Richmond Street
Philadelphia 34, Pennsylvania
Coating and Wrapping

Bell Transportation Company
1406 Hayes Street
Box 8598
Houston, Texas
Stringing and Hauling

C. E. Burn Road Boring Contractor
Box 1
Corpus Christi, Texas
Road Boring

Canadian-Parkhill Pipe Stringing, Ltd.
21 King Street East
Toronto, Canada
Stringing and Hauling

Sam Carline, Inc.
P. O. Box 138
Berwick, Louisiana
James E. Buckner, Gen. Supt.
Marine Dredging
Marine Pipe Line Construction

Centriline Corp.
140 Cedar Street
New York 6, New York
Cement Lining

Chicago Bridge & Iron Company
332 South Michigan Avenue
Chicago 4, Illinois
Engineering Services
Fabrication
Station Construction

Coates Field Service, Inc.
Box 1581
105 NE 23rd Street
Oklahoma City, Oklahoma
Telephone: JA 8-7578
John J. Coates, President
Right-of-Way Acquisition and Services

Coating Engineers, Inc.
4100 Holmes Road
Houston, Texas
Coating and Wrapping

Collins Construction Company
Box 256
Port Lavaca, Texas
Telephone: JA 4-3771
S. V. (Sammy) Collins, Owner
Marine Dredging
Engineering Services
Marine Pipe Line Construction

J. L. Cox & Son
Raytown, Missouri
Stringing and Hauling

Crutcher-Rolfs-Cummings, Inc.
7825 Katy Road
Box 2073
Houston, Texas
Coating and Wrapping
Internal Coating of Pipe

Dravo Corp.
Dravo Bldg.
Pittsburgh, Pennsylvania
Engineering Services
Fabrication
Station Construction

Dunbar & Sullivan Dredging Company
2312 Buhl Building
Detroit 26, Michigan
E. D. Wattles, President
Marine Dredging

Dunn Brothers, Inc.
801 Mercantile Securities Building
Dallas, Texas
Stringing and Hauling

Ebasco Services, Inc.
2 Rector Street
New York 6, New York
Engineering Services

Jess Edwards, Inc.
Box 2287
Corpus Christi, Texas
Stringing and Hauling

Elliott Marine Divers
Box 5512 Drew Station
Lake Charles, Louisiana
Marine Services

Fairchild Aerial Surveys, Inc.
224 East 11th Street
Los Angeles 15, California
Telephone: RI 9-3007
Leon T. Eliel, President
Aerial Survey

Fish Engineering Corp.
Box 2617
Houston, Texas
R. D. Ricketts, Vice President
Engineering Services

Flanders Concrete Coating Corporation
10422 Telephone Road
Box 12188
Houston 17, Texas
Telephone: MI 9-2713
Fred D. Flanders, President
Coating and Wrapping
Concrete Coating

Fluor Corp., Ltd.
2500 South Atlantic
Box 7030
Los Angeles 22, California
Jack McKay
Engineering Services
Station Construction

Flexible Pipe Cleaning Company
9324 S. Norwalk Blvd.
Box 167
Los Nietos, California
Telephone: OX 5-5713
G. G. Ellis, Partner
Internal Pipe Cleaning

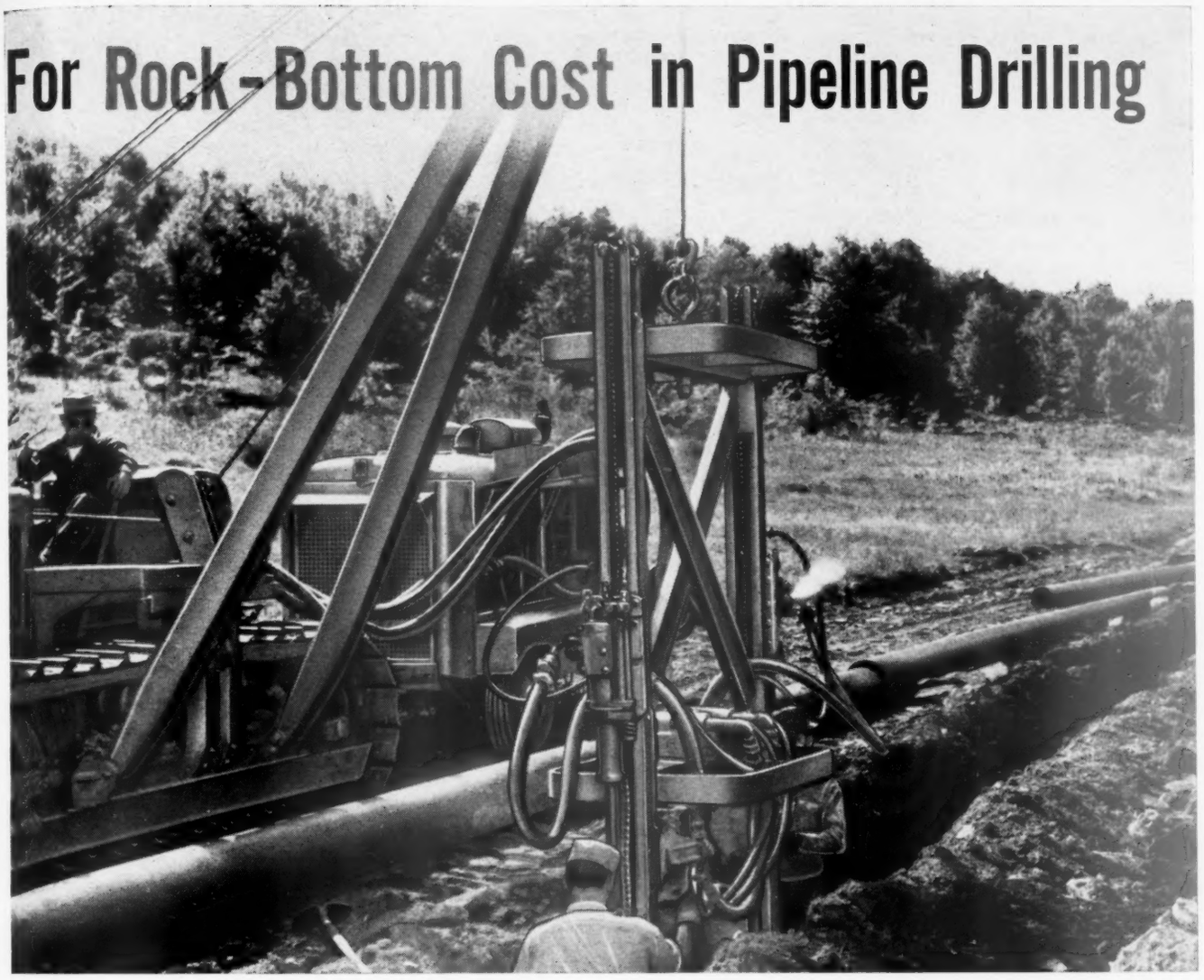
Ford, Bacon & Davis, Inc.
39 Broadway
New York, New York
Engineering Services

Ford, Bacon & Davis Construction Corp.
805 South Grand Avenue
Monroe, Louisiana
Engineering Services

Graver Construction Company, Inc.
332 S. Michigan Avenue
Chicago 4, Illinois
Telephone: HA 7-7042
A. G. Formel
Station Construction

Gulf Coast Pipe Coating Corporation
Holmes Road & Almeda
Box 2091
Houston, Texas
T. A. Morgan, President
Coating and Wrapping

For Rock-Bottom Cost in Pipeline Drilling



use Ingersoll-Rand's

"dual-drill" RIG

For maximum all-around efficiency,
you can't beat this complete I-R team:

- **I-R PLM-2 "DUAL-DRILL" RIG**
- **I-R CARSET JACKBITS**
- **I-R GYRO-FLO 600 COMPRESSOR**

The Ingersoll-Rand "Dual-Drill" Rig is especially designed to permit faster, easier, and lower-cost pipeline drilling. With CARSET JACKBITS, operators drill two holes at a time, with no change of steel and practically no bit changes. Drilling time per hole is considerably reduced and the move to the next position is made in less than a minute.

The I-R "Dual-Drill" Rig utilizes the famous Ingersoll-Rand X71-WD Rock Drills proven for their excellent performance on wagon drills the world over. The Rig comes complete with controls, hose and lubricators on a rugged fabricated steel mounting. Control valves for drill feed, hammer action and hole blowing are at the operator's fingertips, conveniently located on the I-R air-feed motor. Simply hang the rig on your "boom cat", attach the air connections, and you're ready to go.

This "Dual-Drill" Rig, powered by an Ingersoll-Rand Gyro-Flo 600 Compressor and equipped with faster-drilling, longer-lasting Carset Jackbits, gives you a fast-moving combination that pays off many times in reduced cost per foot of trench.

Your nearest I-R representative will be glad to give you the complete story.

5-144

Ingersoll-Rand
11 Broadway, New York 4, N. Y.

Hill, Hubbell and Company
(Division of General Paint Corp.)
3091 Mayfield Road
Cleveland 18, Ohio
Telephone: YE 2-7535
M. M. Bowen, Vice President
Coating and Wrapping

Holden Construction Company, Inc.
515 Commerce Building
Box 496
Pawhuska, Oklahoma
Station Construction

Hoss Heavy Haulers—Pipe Line Division
Box 787
Laurel, Mississippi
Stringing and Hauling

Hudson Engineering Corporation
2711 Danville
Houston, Texas
Engineering Services
Station Construction

Hunsaker Trucking Contractor, Inc.
11476 Harry Hines Blvd.
Box 94
Dallas, Texas
R. B. Hunsaker, President
Stringing and Hauling

Industrial X-Ray Engineers
115 Belmont Avenue, North
Seattle, Washington
X-Ray Services

Percy Jones, Inc.
Box 1083
1131 North Eastern Ave.
Oklahoma City, Oklahoma
Telephone: RE 6-1508
Percy Jones, President
Stringing and Hauling

Loftin & Loftin, Inc.
Delhi, Louisiana
Right-of-Way Clearing/Grading

Mayes Brothers, Inc.
1150 McCarty Drive
Box 2062
Houston, Texas
Telephone: OR 2-7566
H. Boyd Mayes, President
Coating and Wrapping

J. Ray McDermott & Company, Inc.
Box 38
Harvey, Louisiana
Marine Dredging
Marine Pipe Line Construction

McWilliams Dredging Company
903 South Jeff. Davis Blvd.
Box 584
New Orleans 7, Louisiana
Marine Dredging
River Crossings

Merritt-Chapman & Scott Corporation
260 Madison Avenue
New York 16, New York
Engineering Services

Missouri Dredging Company
2100 North Wharf Street
St. Louis, Missouri
Marine Dredging
River Crossings

Missouri Valley Dredging Company
222 William Street
Box 1592
Burlington Station
Omaha 8, Nebraska
Telephone: AT 0372
Joe G. McMaken, President
Marine Dredging
Marine Pipe Line Construction
River Crossings

Parkhill Truck Company
1645 East 21st Street
Box 1856
Tulsa, Oklahoma
Telephone: RI 7-1351
Kenneth A. Owen, President
Stringing and Hauling

Pentzien, Inc.
1504 Dodge Street
Omaha, Nebraska
Telephone: AT 9696
Louis I. Pentzien, President
Marine Dredging
Marine Pipe Line Construction
River Crossings
Engineering Services

Pipeline X-Ray Service
14000 South Main Street
Houston, Texas
C. W. Radcliff, Gen. Mgr.
Radiographic Inspection

Pipe Line Service Corp.
Box 318
Franklin Park, Illinois
Coating and Wrapping

Pipe Protection Service, Inc.
715 Elizabeth Avenue
Elizabeth, New Jersey
Coating and Wrapping

Richardson X-Ray Service
617 South Raymond Avenue
Alhambra, California
X-Ray Services

Road Boring & Tunneling Company, Inc.
6829 Long Drive
Houston 17, Texas
Bill Horner, President
Road Boring

Gleason Romans Pipe Line Patrol Company
Hangar 10, Municipal Airport
Box 8447
Tulsa, Oklahoma
Gleason Romans, President
Aerial Survey
Aerial Pipe Line Patrol

Rosson-Richards Companies
M & M Building
Houston 2, Texas
Coating and Wrapping

Secco Pipe Coating Corporation
Box 9186
Houston 11, Texas
Telephone: WAlnut 6-8803
Syd E. Culbertson, President
Coating and Wrapping

Station Construction Company
Box 13174
Houston 19, Texas
Station Construction

Stone & Webster Engineering Corp.
90 Broad Street
New York, New York
Engineering Services

Tellepsen Petro-Chem Constructors
(Division of Tellepsen Construction Co.)
1710 Telephone Road
P. O. Box 2536
Houston, Texas
Telephone: WA 3-9331
Emery E. Gose, Vice President
Ditching and Excavating
Marine Dredging
Engineering Services
Fabrication
Marine Pipe Line Construction
Station Construction

Texas Road Boring Company
6829 Long Drive
Houston 17, Texas
Gilbert Turner, Partner
Road Boring

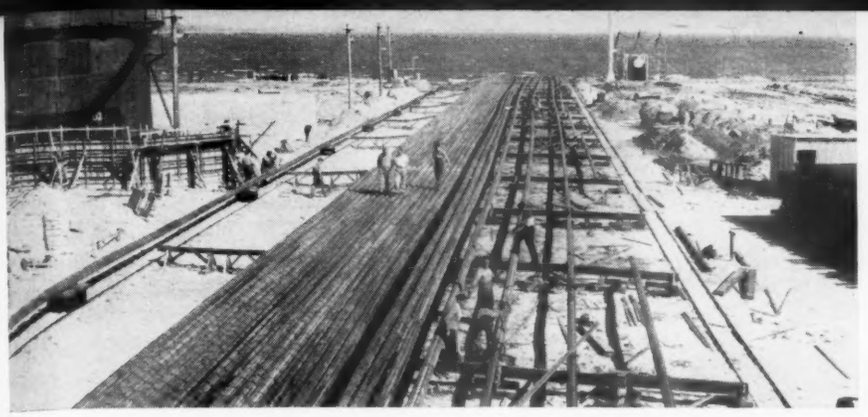
Tuloma Builders
8500 East 41st Street
Tulsa, Oklahoma
Telephone: RI 7-1311
Clyde Wyant, President
Engineering Services
Fabrication
Station Construction

Tulsa Pipe Coating, Inc.
2240 E. Apache
Box 3085, Whittier Station
Tulsa, Oklahoma
Coating and Wrapping

United Engineers & Constructors, Inc.
1401 Arch Street
Box 628
Philadelphia 5, Pennsylvania
Engineering Services

Williams Pressure Service Company
422 Commercial National Bank
Shreveport, Louisiana
Hydrostatic Testing

J. C. "Red" Willett
Box 2836
Monroe, Louisiana
J. C. "Red" Willett, President
Stringing and Hauling



View of launching site at Banksmeadow terminal on north shore of bay. At left is the railroad type launchway, where lead section of the second pipe line is on dollies ready for its trip to the opposite shore nearly three miles away.

P 616.

Botany Bay Line Australia's Longest

Four 17,000-ft, 6-in. products lines laid in bay waters by winch-pull method

THE laying of four lines across Botany Bay near Sydney, Australia, longest underwater pipe line job ever constructed "Down Under" and a major engineering feat, was completed this summer by Merritt-Chapman & Scott Corporation of New York, in a joint venture with Raymond Concrete Pile Company of New York and Fletcher Construction Company, Ltd., of Auckland, New Zealand.

The newly laid lines will be used to carry products from the Kurnell refinery on the south shore to the Australian Oil Refining, Ltd. Banksmeadow terminal on the opposite side of the bay, a total underwater distance of 17,000 ft.

The four lines are part of an expansion program underway in 1955 by Australian Oil Refining in the Kurnell area of New South Wales, in eastern Australia. Other new construction in the area includes a refinery and a tanker wharf in Botany Bay. Australian Oil Refining is an affiliate of California Texas Oil Company (Caltex).

Each of the four lines is 6-in. seamless steel pipe, with a ¼-in. wall thickness. Pipe protection consisted of primer, enamel and glass fiber wrap. Before pulling, the pipe strings were bound with wooden slats to prevent damage to the coating and wrapping during the pull.

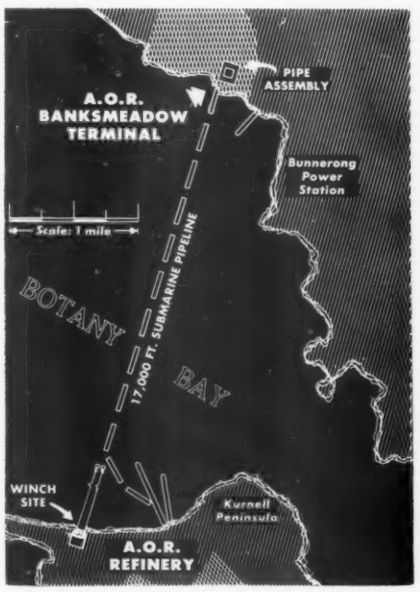
The lines were buried to a minimum depth of 12-in. cover from the shore lines to points in the bay where minimum water depth is two fathoms (12 ft) as protection for nets and lines of fishermen in the area.

To accomplish the pulling job across the bay, M-C&S brought from the United States the huge winch that was used successfully in pulling the Straits of Mackinac crossing in late 1953.

Each of the four lines was pulled individually. Pipe was made up into 520 ft sections on the Banksmeadow side of the bay. A railroad type launchway was set up to handle the pipe during pulling. The winch unit was installed on the Kurnell side of the bay.

To power the huge winch, which has a direct pulling power of 50 tons, a 500-hp ship's boiler was converted on the job site. The steel cable used in the pulling operation was 1½-in. diameter.

Map shows route of submarine line across Botany Bay.



At the lead end of the first section being pulled, an oversized mandrill was welded to the pipe and the cable attached. The added buoyancy of the mandrill provided a safety factor in keeping the cable off the sea bottom where it could be damaged.

As each 500-ft section was pulled to the edge of the launching area, the cable was stopped and another section welded on to the line, inspected, doped, and launching begun immediately after receiving an inspection "okay". Two-way radio communication was used throughout the operation, which continued on a 24-hour basis until each of the four 17,000 ft sections was pulled.

During the pulling operation, it was necessary to stop the winch at 2000-ft intervals, raise the line from the water, remove the mandrill, and then remove a 2000-ft section of cable from the winch to make room on the winch drum.

Removing and changing the mandrill was a delicate task. After each 2000-ft pull, it was pulled ashore at the winch site and slacked off clear of the ground. The accumulated twist spun the mandrill rapidly until the cable behind it had resumed almost normal tension. Then a lighter line was run from the winch to the shore end of the cable, detouring the mandrill, which was then uncoupled from the cable. It whipped around until it regained normal tension. The mandrill was then hauled back to the barge, the next 2000 ft of cable attached, and the mandrill attached to the pipe end.

The discarded 2000-ft lengths of cable were then transferred to a hauling barge and stored until the next complete pull job was started.

During night operations, two strings of lights were set up as guides. One string was set vertically, the other horizontally.

The sealed line, filled with air, retained a negative buoyancy of approximately 3 lb per lineal ft during the pull, sufficient to keep the pipe from floating to the surface, but not enough to cause excessive friction and resistance on the bay bottom to give the pulling winch trouble. A float was also attached to the mandrill from the barge that accompanied the pipe on its journey across the bay, keeping the mandrill and cable from dragging the ocean floor.

To insure that no obstacles would snag the line, a diver surveyed the entire route across the bay bottom.

Upon completion of the four separate pulls, the entire operation was given a thorough underwater inspection by a diver. At the deepest point on the underwater route, the lines lay 36 ft below the normal bay water surface.

Construction Report

Great Lakes Pipe Line Nears Completion of Two-Year Program

Now in its 25th year of operation, nation's oldest common-carrier products pipe line has nearly 5500 miles, over 200,000 bbl daily capacity

Map shows route of extensive, nine-state Great Lakes Pipe Line system throughout Middle West.

In 1954 and 1955 Great Lakes Pipe Line Company increased capacity of its system by construction of a new terminal, nearly 1000 miles of line, building four new pumping stations and adding power at others, and additional facilities at several terminals.

Sole extension to the system consisted of a 131-mile, 8-in. line from Nebraska City to Doniphan, Nebraska, midway between Hastings and Grand Island, where a new terminal was built. This line is powered by an electric unit at the existing Nebraska City station. A remote controlled electric station at Lincoln provides available reserve capacity. The Doniphan terminal has 14 tanks, each with a capacity of 40,000 bbl. Deliveries for shippers are made into motor transports and railroad tank cars.

All other line construction was designed to furnish larger capacity for restricted sections of the system.

El Dorado-Kansas City Line

South of Kansas City, a 10-in. line was laid direct from El Dorado, Kansas to Kansas City to supplement the 8-in. line from El Dorado, which joins the Great Lakes system at Humboldt, Kansas. The 10-in. line is powered by a diesel unit at El Dorado. A remote controlled diesel unit, the first of its kind for the company, will furnish power at Topeka when needed.

Kansas City-Des Moines Loop

A second 12-in. line was constructed from Kansas City to Des Moines parallel to two 8 and one 12-in. lines. Power for 100 mile operation of the line is supplied by two electric units at Kansas City and two diesel-driven pumps at Ridgeway, Missouri.

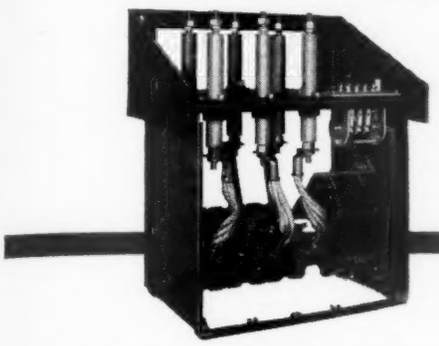
Currently near completion is a 12-in. line from Des Moines to Iowa City along the route of 6- and 8-in. lines. The new line will be powered the entire distance from Des Moines by an electric unit.

Iowa-Illinois Line

Earlier in the two-year construction program, an 8-in. line was built from Iowa City to a point near Middlebury, Illinois where it connects with the Badger Pipe Line to terminals at Rockford, Illinois and Madison, Wisconsin. Products consigned to these terminals through the Great Lakes system are pumped by the company's station at Prophetstown, Illinois, where a second electric unit was added.

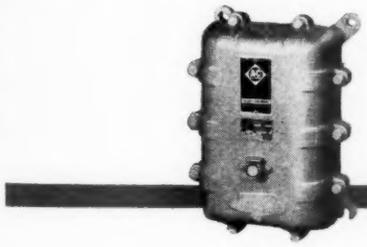
These Safety Features

meet operating demands of combustible atmospheres



Oil-immersed main contactor for safe operation

The complete contactor, including magnet and auxiliary switches, operates under oil to prevent sparks from igniting atmosphere and to protect mechanism from corrosion.



Relays and switching devices in explosion-proof cases

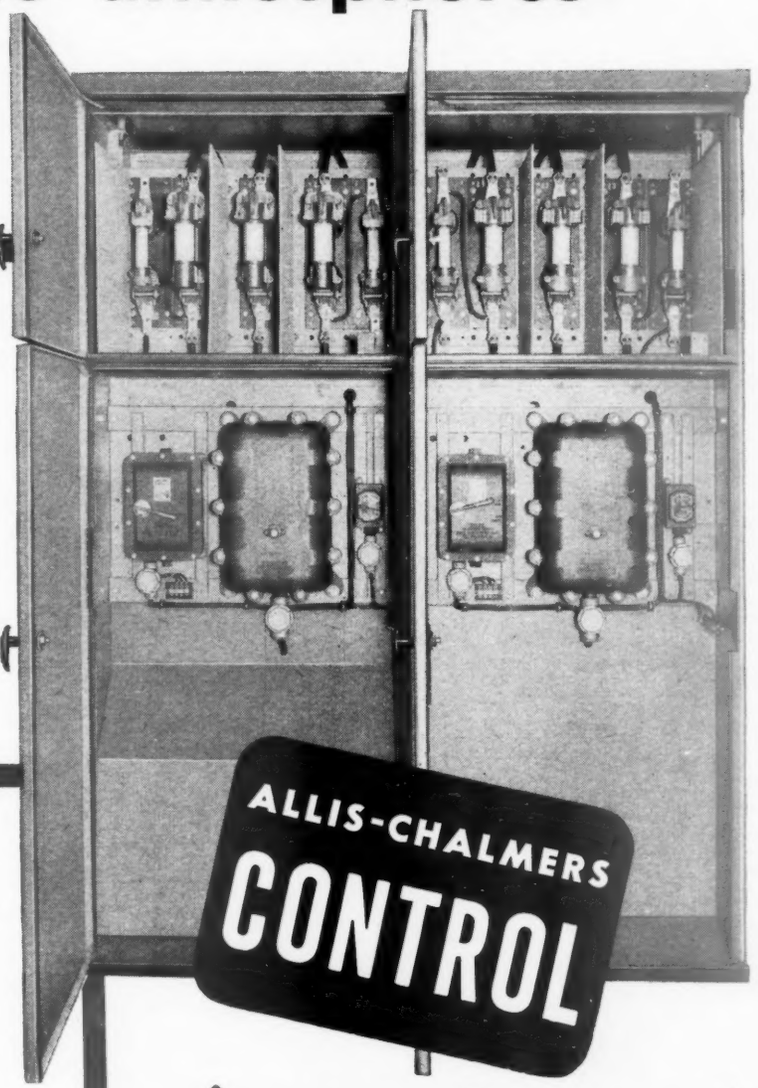
Further protection against the possibility of explosion is provided by NEMA VII enclosure which houses all overload, undervoltage, timing and auxiliary control relays as well as other low voltage switching devices.

Interlocked fuse compartment door

The fuse disconnect door is interlocked. The line contactor must be opened before access to the fuse is possible.

Other features *Steel barriers* in rear compartment prevent accidental contact with high voltage parts. Enclosure is finished with corrosive-resistant paint. Indoor or outdoor control equipment may be provided.

A-4583



Industry-Engineered

for Semi-Hazardous Locations

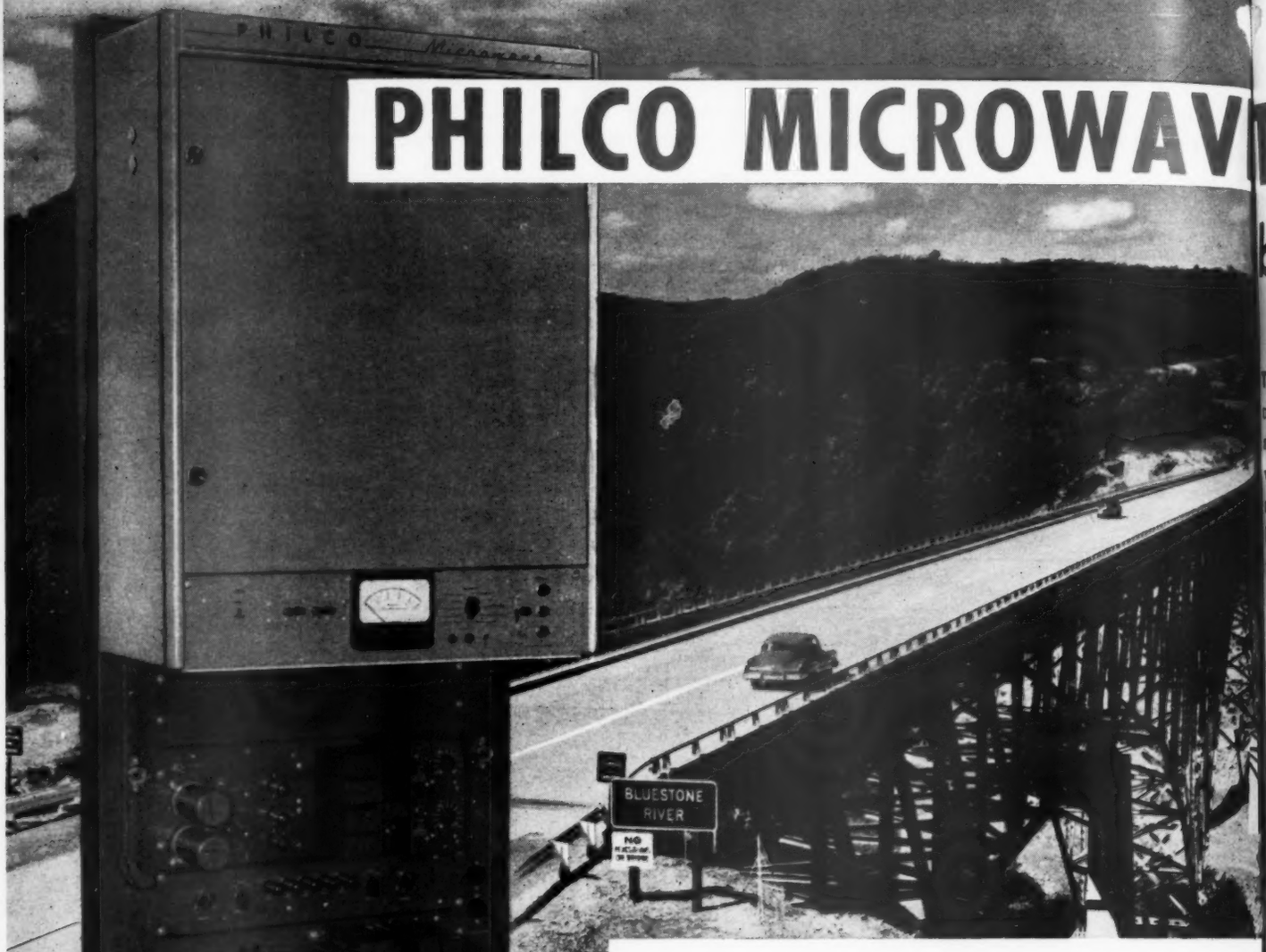
Type H starters for 2300 to 5000-volt motors

For complete information, see your Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wis.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

PHILCO MICROWAVE



New Philco Model CLR-7 Repeater.

PRODUCTION and plant efficiency can be stepped up to new highs . . . easily . . . automatically . . . with versatile, economical Philco microwave. Turnpikes, utilities, pipelines, and railroads prove Philco microwave a powerful tool to increase productive output . . . and actually cut costs!

From one central point—and over great distances—Philco microwave gives you direct control of important operations. Philco microwave places hundreds of vital functions right at your fingertips. Two-way communication is private—push-button control gives *instantaneous action at remote points!*

Philco, *world's leading microwave manufacturer*, maintains an experienced and skilled technical staff available to you for systems planning, installation and service. For information, write Philco Department PE today.

TEPS UP EFFICIENCY

by *Centralizing* Plant Control!

TURNPIKES use Philco microwave for traffic control. Over rough terrain, fully automatic Philco microwave systems provide a reliable, low-cost means of communication to meet emergencies, keep highways clear of possible blocks . . . maintain contact with radio-equipped cars and trucks . . . 'round the clock.

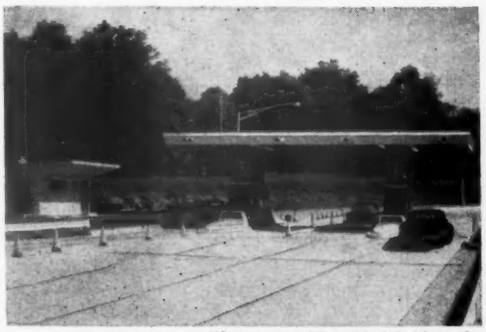


Photo courtesy West Virginia Turnpike

PIPELINES use Philco microwave for automatic operation. At this control center, pressures and flow rates of oil, operation of pumps, compressors and telegraphic printers, throughout this 1000-mile pipeline, are monitored and automatically controlled. Duplex voice communication is provided from one location to another.

Photo courtesy Platte Pipe Line

RAILROADS prove Philco microwave dependable. Philco microwave has proved to be a reliable and dependable means of communication, even during floods and storms when vulnerable wire lines have failed. Voice communication, telegraph and teletype are transmitted instantly to remote stations along the route.

Photo courtesy Santa Fe Railroad

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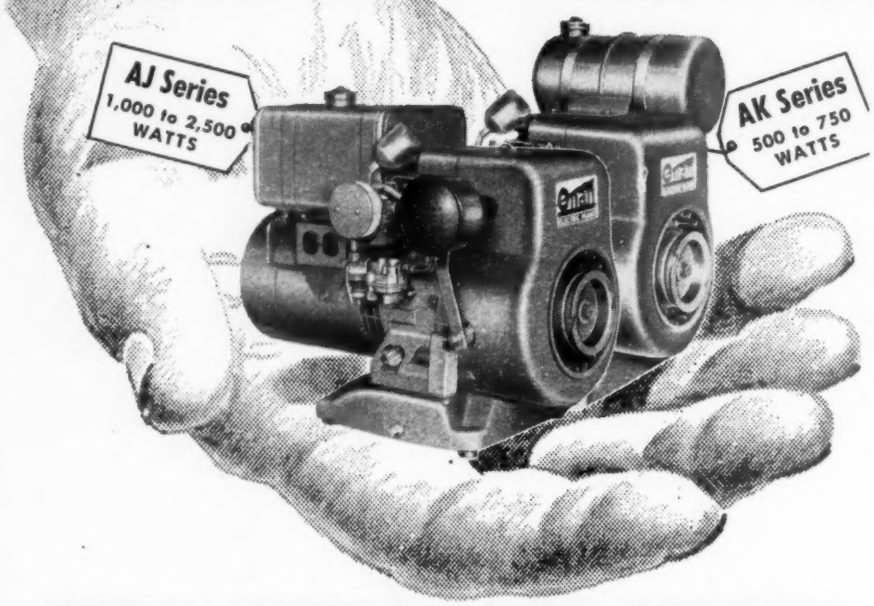
ONAN Announces Two New Series of POWER PACKED ELECTRIC PLANTS



MORE POWER, LESS WEIGHT, SMALLER SIZE, LOWER COST!

2,500-watt unit weighs only 154 pounds! Gives you more power per dollar than any other 4-cycle electric plant.

Higher output in a smaller, lighter package gives these new Onan units marked advantages for every type of service . . . portable, mobile, primary, or emergency standby.

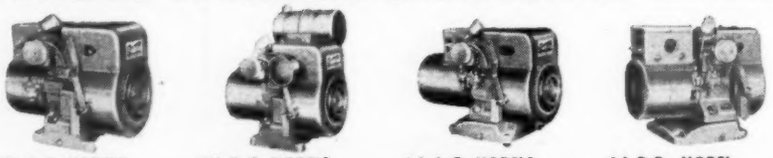
Wherever you use *portable* electric plants, you can now put more cost-cutting electric light and power to work for you . . . at less cost. In *mobile* applications you can take along more power in less space . . . with less weight. In *primary* and *emergency* standby applications you get more power at less cost with all the Onan advantages of quick starting, long life and easy maintenance.

These new units are *completely Onan-built,* with Onan engines direct-connected to Onan generators in a single compact unit. The new, modern, *short-stroke,* single-cylinder, 4-cycle engines feature extra-large bearings and free-breathing intake and exhaust systems to give you thousands of hours of operation without major servicing. Generators are drip-proof and specially insulated for all-climate, all-season use.

Equipped with carrying frames or two-wheel rubber-tired dollies, Onan AJ and AK series electric plants can be taken anywhere . . . moved around easily on the job.

See your Onan distributor or write for new folder describing all 18 new models

POWERED BY MODERN SHORT-STROKE ENGINES



AK A.C. MODELS 500 and 750 watts, 115 or 230 volts.

AK D.C. MODELS (Battery chargers) 500 and 750 watts, 6, 12, 32 volts.

AJ A.C. MODELS 1,000 and 2,500 watts, 115 or 230 volts.

AJ D.C. MODEL (Battery Charger) 1500 watts, 32 volts

D. W. ONAN & SONS INC.

3219 University Ave. S.E., Minneapolis 14, Minnesota

New Amboy Terminal

In August, 1954, Great Lakes began deliveries into a new terminal at Amboy, Illinois. This is the only location where shipments are delivered directly into a facility owned by shippers.

Four Remote Stations

Four of the stations on the 6 and 8-in. lines east of Des Moines have been converted from diesel to electric power and are operated by remote control from Iowa City. Repowering of the 6-in. line to Chicago and changing from reciprocating to centrifugal pumps, permitting the line to be operated at higher pressures, has increased its inherent capacity by approximately 2000 bbl a day.

The diesel station at Oxford, Iowa, adjacent to Iowa City, was replaced by a new station at Iowa City. It also houses the supervisory equipment for control of the three electric stations to the east—at Donahue, Iowa, Prophetstown, and Dixon, Illinois.

Minnesota Line Capacity Upped

South of Minneapolis, capacity of the 12-in. line to Minneapolis was improved by converting it from 100-mile to 50-mile pumping. This was done by adding units to the line at existing stations; two each at Roland, Iowa and Albert Lea, Minnesota and a single unit at Faribault, Minnesota. The Roland station was changed from diesel to electric power, both on the 12-in. and two 6-in. lines. The units will be controlled from Des Moines.

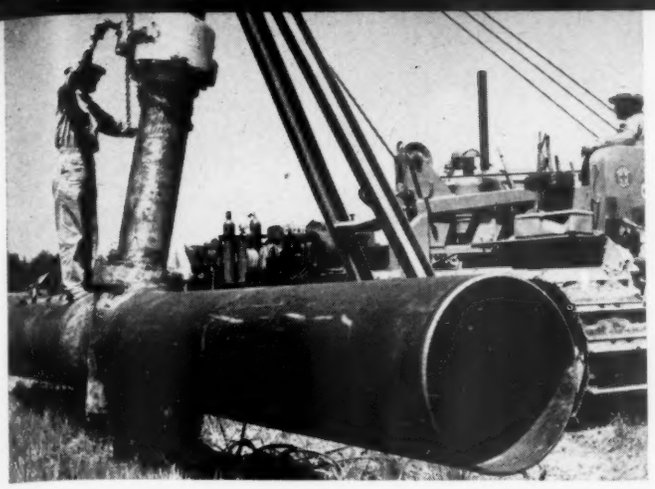
A 12-in. line was laid from Rosemount, Minnesota, south of St. Paul to Willmar, Minnesota where it parallels an 8-in. line to the Alexandria, Minnesota terminal. From Alexandria, an 8-in. line to Fargo was built along the route of a 6-in. line to supply that terminal and allow greater use of the 6-in. for pumping to the Grand Forks, North Dakota terminal.

New Tankage Added

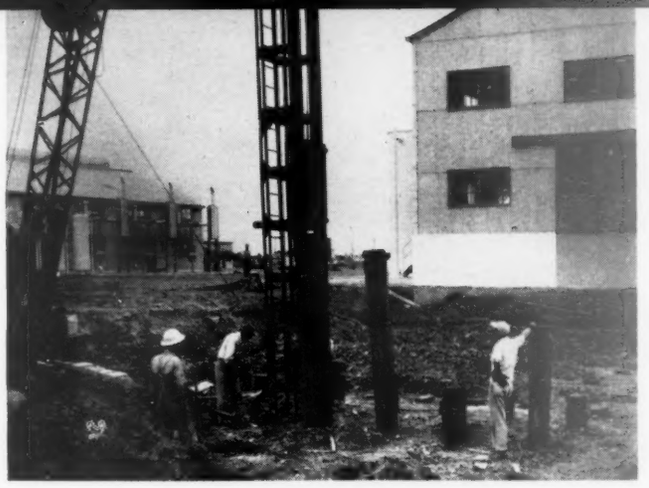
An electric station constructed at Rosemount powers the new 12-in. line and six tanks consisting of four 40,000-bbl capacity and two 80,000-bbl provide storage for products at Rosemount. The 105-mile, 8-in. line from Alexandria to Fargo is pumped by a diesel unit added at the Alexandria station.

Three additional 40,000-bbl tanks were constructed at the Mankato, Minnesota terminal and two 40,000-bbl tanks will be erected at Iowa City.

Because of increased motor truck deliveries from Kansas City and Iowa City loading facilities at each of these terminals have been expanded. * * *



Gate valve on 26-in. loop near Covington, Tennessee, is readied for installation. Nearly half of 1955 program was 26-in. loops.

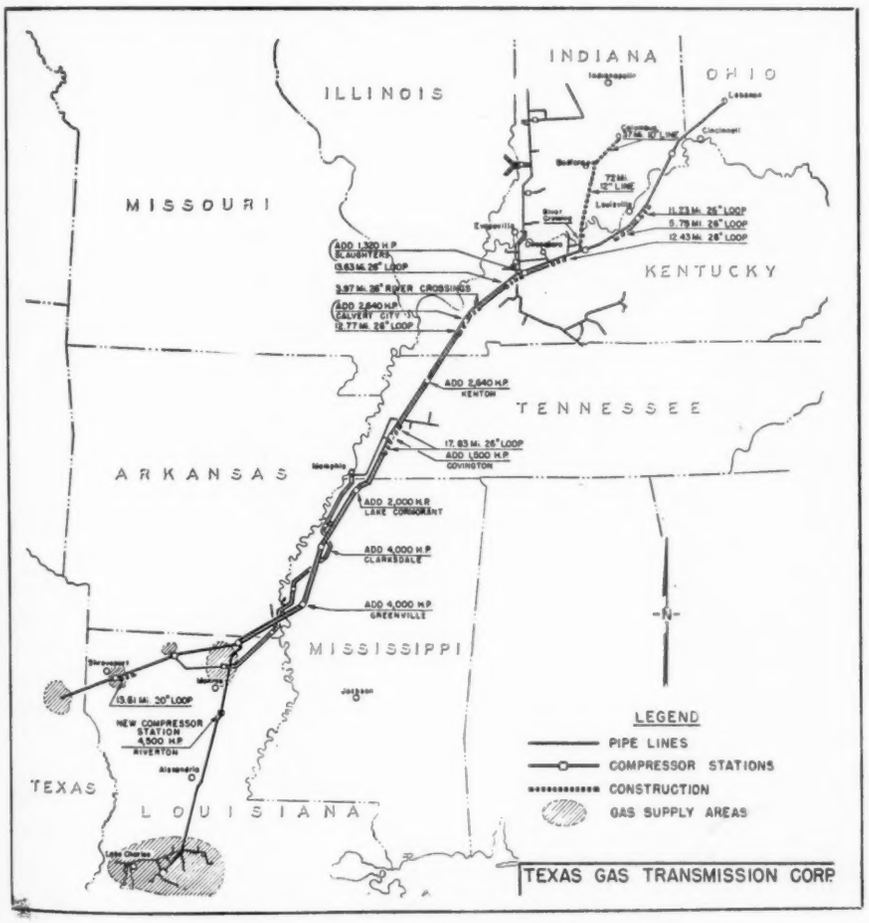


Prior to placing foundations for two additional 2000-hp compressor units at Greenville, wooden piling is driven into ground for added support.

P 623

Texas Gas Adding 210 Miles, 22,600-hp To System In 1955

New facilities add 105,000,000 cu ft daily capacity; 1956 plans call for 200 more miles of line, 12,650-hp, other facilities



Map shows Texas Gas Transmission Corporation's system and location of facilities added in 1955.

As the First Phase of an Impressive expansion program designed to make possible increased peak-day deliveries to its firm customers, Texas Gas Transmission Corporation is adding 210 miles of pipe line and over 22,000-hp to its facilities.

The new lines and horsepower will make possible delivery of an additional 105,000,000 cu ft per day and will also make possible proposed off-peak sale of up to 18 billion cu ft per year to American Louisiana Pipe Line Company. Completion of the 1955 program is anticipated prior to the winter heating season.

To follow this year's projects, Texas Gas recently filed application with the FPC for approval of a 1956 construction program costing $20,000,000 that will include approximately 200 miles of pipe line, two new Mississippi River crossings, 7620-hp at two new compressor stations, and addition of 12,650-hp to existing stations.

This proposed program will allow Texas Gas to further increase peak-day deliveries by another 109,000,000 cu ft per day. The application contains a proposal for a 110-mile 12 and 20-in. line connecting the company's main line system with a new gas producing area on the Louisiana Gulf Coast. Also asked is permission to lay a fifth parallel line of 30-in. diameter in Arkansas and Mississippi, where the company now has two 26-in. and two 18-in. lines. Smaller diameter line additions are planned in Louisiana, Tennessee, Kentucky, and Indiana. A new 6000-hp compressor station is planned near Alexandria, Louisiana, and 12,650-hp in other compressor additions at stations in Louisiana, Mississippi, Tennessee, and Kentucky.

Seven loops and a system extension mark the 1955 line construction program. Near Shreveport, Louisiana, a 13.61-mile, 20-in. loop was laid from Haughton station parallel to an existing 20-in. line. The other segments of

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Long pull across the Kentucky River just below Kentucky Dam. Similar crossing was made few miles away across Cumberland River, both jobs by Pentzien, Inc. River clamps weigh 4500-lb each, made of cast iron. Pipe and clamps were coated with plasticized coal tar enamel.

six looped lines are all 26-in. and include 17.83 miles near Covington, Tennessee, and a total of 55.84 miles at various points in Kentucky.

The system extension includes 78 miles of 16-in. from the Hardinsburg, Kentucky station to near Bedford, Indiana, a 37-mile, 10-in. line to near Columbus, Indiana, and a 5-mile, 8-in. line to Bedford.

Contractors on the line construction include Houston Contracting Company, Houston, who laid the 20-in. loop, and H. C. Price Company, Bartlesville, Oklahoma, builder of the other six loops and the Indiana extensions.

Compressor Additions

One new station and compressor horsepower additions to six existing stations are also included in the 1955 program. On its main 26-in. line between Eunice and Bastrop, in Louisiana, the company has added a 4500-hp station near Columbia.

Additions to existing stations include:

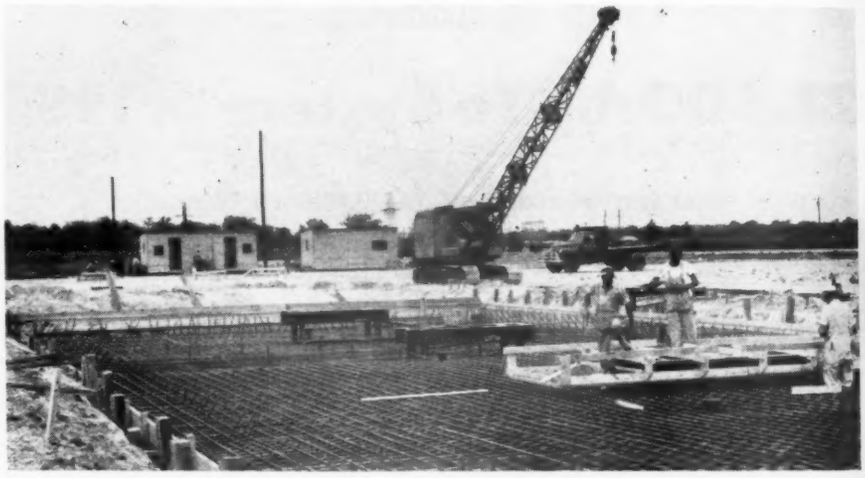
At Greenville, Mississippi, 4000-hp
At Clarksdale, Mississippi, 4000-hp
At Lake Cormorant, Mississippi, 2000-hp
At Covington, Tennessee, 1500-hp
At Kenton, Tennessee, 2640-hp
At Calvert City, Kentucky, 2640-hp
At Slaughters, Kentucky, 1320-hp

River Crossings

Three major river crossings are included in the 1955 program. Near Gilbertsville, Kentucky, both the Kentucky and Cumberland Rivers are being crossed, a total of 3.97 miles of 26-in. river pipe.

A third major river crossing is being made on the Ohio River on the route of the Indiana extension. The Ohio crossing of 0.95 miles will be made with two 12-in. lines.

All three crossings involve navigable streams, with light to heavy traffic. They were constructed using the pull method by Pentzien, Inc., of Omaha, Nebraska. On the two 26-in. crossings, 4500-lb cast iron river weights were placed at 18-ft centers to provide needed negative buoyancy.



Lots of reinforcing rod steel is evident in this main slab for new compressor station.

Rain—and the subsequent mud—made for difficult going in Louisiana during laying of the 20-in. loop line.

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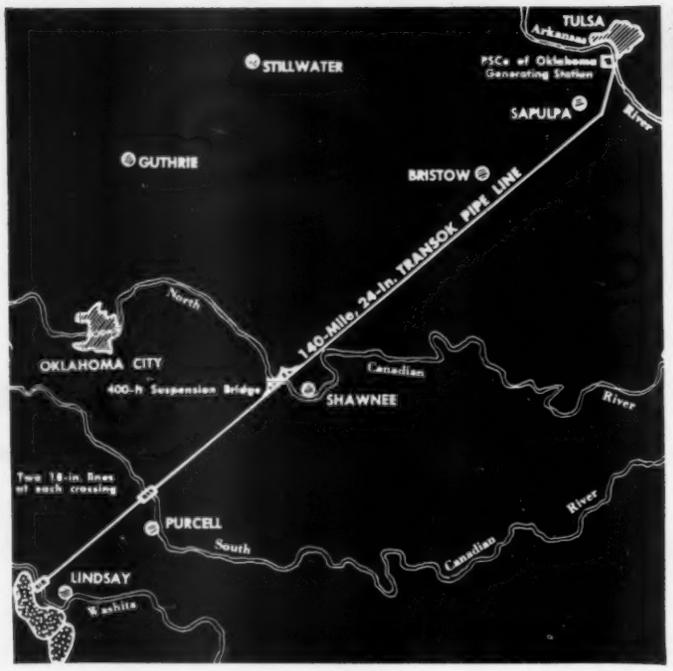

Line extends from near Lindsay to Tulsa

Concrete river clamps were used on the Washita.

Answer to Phillips Decision

Transok: *New Intrastate Pipe Line*

System built to market inside state boundaries gas that had been earmarked for interstate shipment

TRANSOK Pipe Line is the first transmission system of major proportions to be constructed as an answer to the Supreme Court's decision in the Phillips Case. Being entirely within the state boundaries of Oklahoma there is no Federal Power Commission jurisdiction over the price of gas at the wellhead. Unless legislation is passed to alleviate the unpopular situation created by the high courts ruling, unquestionably there will be increasing activity to develop markets within the states where gas is produced, of which the Transok project is but a single example.

The 140-mile, 24-in. line was built for the sole purpose of supplying fuel to a large electric generating plant at Tulsa of the Public Service Company of Oklahoma, which requires about 9,000,000 cu ft an hour. It originates about three miles west of Lindsay, Oklahoma. Gas production is from the Northwest Purdy, Bradley, and West Lindsay fields, and is production that had been earmarked for interstate shipment prior to the Supreme Court's decision in 1954.

In addition to the main line, gathering lines and compressor facilities were installed by Phillips Petroleum Company and Magnolia Petroleum Company, who will deliver dry gas to Transok. Transok has commitments with these two companies for one trillion cubic feet of gas over a 25-year period and a contract with Public Service Company to supply its fuel requirements during this period.

A natural gasoline plant, 3 miles west of Lindsay, owned jointly by Phillips and Magnolia and operated by Phillips is removing liquid hydrocarbons and discharging the dry gas into Transok's line at a pressure of 700 psi. This is the only boost given the gas, which is received at Tulsa at 150 psi. The gas has been contracted from Phillips and Magnolia on a basis of 12 cents per Mcf with price adjustments to come later. The first increase will be to 18 cents within a few years, later to the going field price as determined by a committee of independent investigators.

The gasoline plant, known as the Bradley plant, has an initial installation of four 1350-hp compressors. Ultimately there will be 19 1350-hp compressors. The plant's gathering system consists of 116 miles of line ranging in size from 2 in. to 30 in.

Transok Pipe Line is headed by John M. Winters, Jr., Tulsa attorney, as president and treasurer. Other officers are Roger S. Randolph and Horace D. Ballaine, vice presidents; C. C. Killin, vice president, secretary, and assistant treasurer; J. R. Ryan, assistant secretary, and P. H. Kuper, comptroller. All are members of the same law firm as Winters.

Construction Methods

Route of the system is almost on a direct northeast line from the point of origin in south-central Oklahoma to Sapulpa, where it turns more sharply north into Tulsa. Right-of-way was principally through sandy loam until it entered Creek County. Most of this

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IS IN YOUR SPREAD
ON YOUR NEXT JOB—
YOU'LL MAKE MORE MONEY WHEN YOU DO

THEY'RE *Good* *Everywhere*

Lining up pipe and running stringer bead at a point near Shawnee, Oklahoma.

About 20 per cent of the welds were tested for quality by X-raying.

county, approximately 35 miles, is underlain with rock, which required virtually 100 per cent blasting to make ditch.

An essential part of the construction was installation of three river crossings, two underwater, and one suspension type. Two 18-in. lines were laid under the Washita River, 2 miles due west of Lindsay, and the South Canadian, 6 miles north of Purcell. The suspension bridge was over the North Canadian 3 miles west of Shawnee. Wall thickness of pipe used on the underwater crossings was ½ in., heavier than for the rest of the line, to give added weight and provide longer pipe life. Additional weight was given by means of concrete river clamps weighing 5500 lb each and spaced on 18-ft centers. As protection against corrosion, extra thickness of coal tar enamel coating was applied and glass fiber and felt wrappers used.

The bed of the Washita River was 100 ft wide at the point crossed, but the dual 18-in. lines were laid for a distance of 2200 ft, as the bottom land through which the river bed winds is subject to floods. The river bed was dehydrated by sandpointing and trench dug with clamshells. Under the bed of the river, the pipe was buried to a depth of 8 ft.

The same procedure was used on the South Canadian crossing. Here the distance was 1800 ft for each line, a total of 3600 ft of pipe.

The suspension span over the North Canadian measures 400 ft and is 35 ft above normal water level and 15 ft above the high point on each bank.

The single construction spread averaged 9000 to 10,000 ft a day. The longitudinal weld pipe used on the main line weighed 71.25 lb per foot and had a wall thickness of 0.281 in. As a check on quality of welds, spot checks were made by X-ray of about 20 per cent of the joints, except on river and highway crossings where all joints were so tested. Protection against corrosion was provided by a 3/32-in. coal tar enamel and wrappers of 15-lb felt plus glass fiber.

Contracting Firms

General contractor on the project was Pipeline Service Company of Seminole, Oklahoma, which installed all three river crossings as well as the main line. Oakley Engineering Company, Tulsa, performed the engineering duties connected with design and construction. Cleaning, coating, and wrapping were subcontracted to Secrest Pipe Coating Company of Tulsa. Pipe stringing was by Parkhill Truck Company and weld testing by Thayer X-Ray Service Company, both of Tulsa.

Welders, shaded from the sun, make finishing welds (below). At right pipe is being coated and wrapped, "jeeped," and cooled with a water ring.

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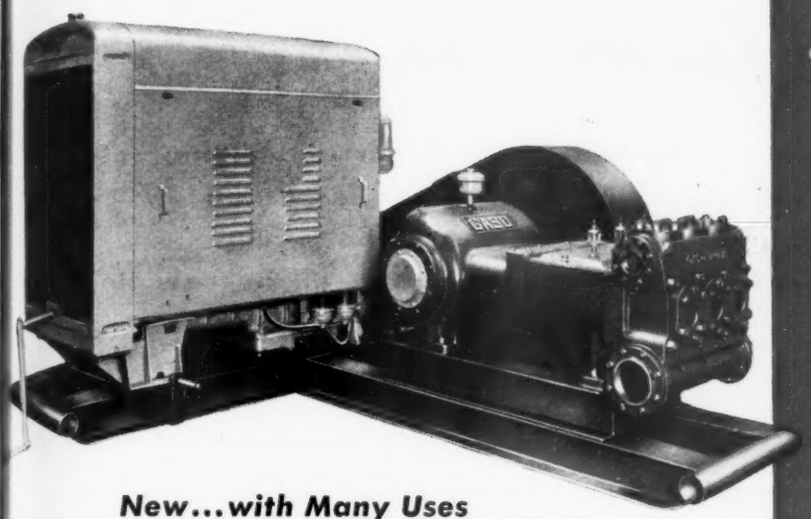

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Type

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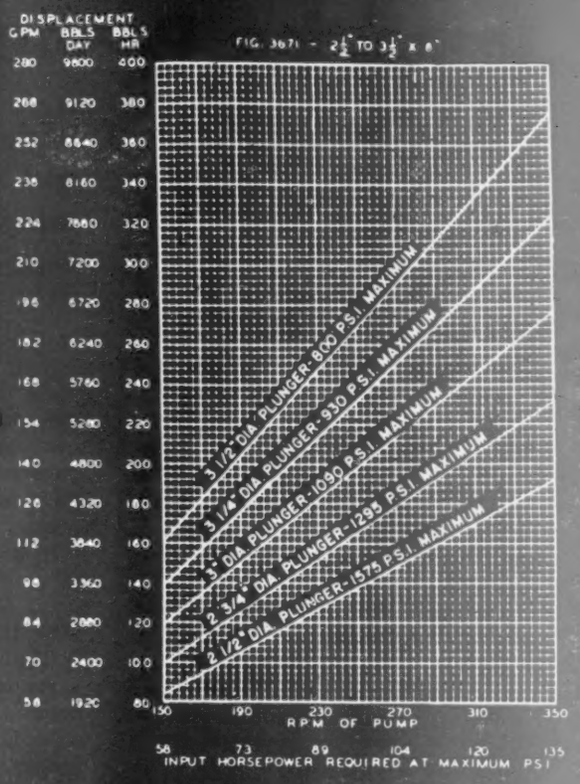

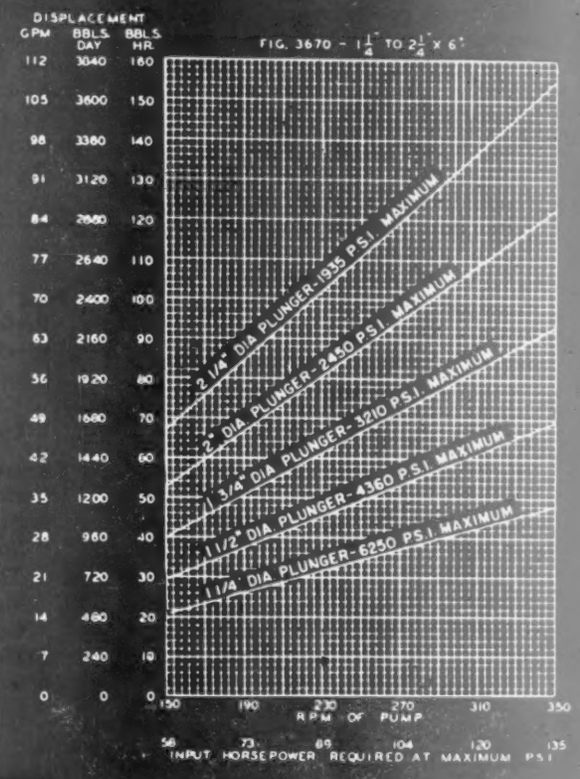

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Inspection During Construction

Design is only half the problem of building safe and reliable pipe lines; proper inspection completes the task. Here are the methods used by Gulf Interstate on its new line

Norman F. Blundell
Chief engineer, Gulf Interstate Gas Company

IN general, the problem of inspection falls under two categories. First, the inspection of material during its manufacture, which, of necessity, means inspection at the plant site. Second, inspection of the activities of the contractor during construction.

The major material inspection job, of course, is the inspection of the pipe at the steel mill, and our general practice has been to hire this service done by an engineering concern that specializes in this type of inspection. We have found this service satisfactory.

It might be pointed out, however, that certain problems arise during construction that require special inspection at the mill. We have found on occasion that the ends of longitudinal welds have been cracked, and in order to cut down the incidence of these cracks, we have required extra inspection at the mill of a non-destructive type. We have required both painting of end welds with dye and use of X-ray to find these minute cracks that cannot be picked up by visual inspection.

A second major inspection job at the mill has developed with the increased use of concrete-coated pipe in the swamp lands of southern Louisiana and the Gulf Coast of Texas. Because of the cost of application of concrete coating, it is highly desirable that this coating be held to a minimum, and because it is held to a minimum, it is important that it stay on the pipe during shipping and construction.

For this inspection, an outside testing laboratory was hired to inspect the work, the basic job being to run specific gravity tests, thickness tests, strength tests of the concrete, and to control the curing. The coating of the pipe is usually performed by the same company that applies the concrete. Inspection of the coating has to be done at the mill, and our practice is to put our own coating inspector at the mill for this work. This may be handled, however, in conjunction with the inspection of the concrete.

There are certain other special items of material that have to be inspected at the mill, this material usually going into compressor stations, and, for this purpose, company personnel are sent to the plants for periodic inspections. Some of these items are engines, pressure vessels, vibration dampeners, and meter runs.

Line Inspection

The major inspection job, of course, is the inspection of the pipe line contractors during construction. The policy on a large job is to break the whole project into divisions.

The division engineer is in complete control of both pipe line and compressor stations for his area. His job involves personnel control and material control. Each spread within a division is set up with a chief inspector in charge.

The basic crew for a major spread of large-diameter pipe in dry areas (as contrasted with swamp or offshore work), consists of a chief inspector and five other inspectors, namely—a pipe inspector, a welding inspector, a paint inspector, a lowering inspector, and a clean-up inspector.

In addition, each spread has an engineer or party chief with at least a two-man survey crew whose job it is to resurvey ahead of the spread and to make the final survey after the spread. Each inspection crew has a material clerk and a radiographic unit for weld inspection.

This inspection crew is augmented with additional personnel for special reasons depending on the terrain or conditions encountered. A 30-in. spread with proper terrain conditions and weather will have a progress of 8000 ft to 11,000 ft per day. When this

GUIDE TO INSPECTION

Pipe Inspection at Mill
Performed by engineering concern specializing in this type of service, using:
- X-Ray
- Painting end welds with dye

Concrete-Coated Pipe
Performed by outside testing laboratory, includes:
- Specific gravity tests
- Thickness tests
- Strength tests
- Curing control

Performed by pipe line company personnel:
- Inspection of coating prior to application of concrete

Compressor Station Equipment
Performed by pipe line company personnel, includes inspection of:
- Engines
- Pressure vessels
- Meter runs
- Vibration dampeners

Line Construction
Division engineer has complete control of all construction in his area; his job involves both personnel control and materials control.

Each spread has a basic crew of:
- Chief inspector in charge of
  - Pipe inspector
  - Welding inspector
  - Paint inspector
  - Lowering-in inspector
  - Clean-up inspector
  - Ditch inspector (when needed)
  - Engineer or party chief
  - Two-man survey crew
  - Materials clerk
- Radiographic inspection unit (outside firm)

Special inspection crews are needed for:
- "Wet" spreads operating in swampy country off a laying barge
- River crossings (under supervision of an engineer)
- Station construction (supervised by a resident engineer)
- Other special work (assigned to an assistant engineer)

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occurs, the contractor will have from 44 to 54 welders on his payroll. This, obviously, has gotten beyond the abilities of one welding inspector. An additional man is needed, in these instances, back with the lowering-in crew. In areas where considerable rock is encountered, it usually becomes necessary to add a ditch inspector. In areas where there are extensive tile installations, it usually is necessary to have a tile inspector.

Radiographic Inspection

Our policy is to radiograph at least 10 per cent of all welds. This service is contracted on a basis of stand-by rate plus a unit price for each weld radiographed. We have used various types of equipment, usually based on terrain and the amount of coverage required. In other words, we use X-ray equipment where the terrain is good and where high footage is obtained by the contractor. We use gamma-ray equipment in inaccessible areas where it is hard to get equipment to the line and where pipe progress is relatively slow.

As an added inducement for surveillance by the contractor's men, we post a cash reward offer for any defect found by a contractor's man. We particularly stress that they look for laminations and cracked welds. The buffers and welders, of course, have the best chance of collecting this reward. It has been very effective.

'Wet' Spreads

There is a special pipe line spread classified as a "wet" spread that requires a different type of inspection crew. This crew operates from a barge, and the organization structure is quite different. As pointed out before, the paint has been inspected at the mill. It is only necessary to inspect the field joints. We, therefore, only use a chief inspector and a welding inspector on the laying barge, and a radiographic unit to test the welds. It is possible on this type of construction to get a 100 per cent coverage, although we don't hold up laying operations to obtain 100 per cent coverage. The ditch, which in this case was a canal, has to be dug prior to the laying operations, and we depend upon our chief inspector to make periodic checks of the canal operation. The inspection crew is doubled where the contractor elects to conduct a two-shift operation.

River Crossings

A special inspection crew is also set up for a major river crossing such as the Mississippi. While the pipe laying operation has a chief inspector in charge, with a welding inspector as an assistant, one of the major overall inspection jobs is under the supervision of an engineer. He has a chief of party with two men in his survey crew. His main job is to keep constant controls and records on the excavation, on the pipe laying, and later on the backfilling operation.

One of his most important instruments is a fathometer because a river of this type is too deep and swift to sound by the normal lead line method. If, as in some of the cases, the coating is done on the job site, a dope inspector has to be added to the crew. The company's engineer at the river crossing does the necessary inspection of the concrete coating.

Station Construction

The other major task of inspection that will be encountered is during the construction of compressor stations. It is our practice to put a compressor construction job under the supervision of a resident engineer, who has a crew consisting of an assistant engineer and a material clerk. During the period when welders are to be tested, a welding inspector from the nearest pipe line spread is sent in, and when sufficient welds have been made to warrant the expense of moving in a radiographic crew, a crew is sent in and 100 per cent coverage is taken of the gas piping in the station yard. When stations are in an area where there isn't a pipe line spread nearby, one welding inspector is assigned to two compressor stations. He also takes care of any special intermediate work such as the installation of meter stations, side taps, etc.

For any special structures, other than the work listed above, the work is assigned to an assistant engineer. Examples of this type of work are warehouses, calorimeter buildings, check measuring stations, and sales meter stations.

Instruction Manuals Useful

As a means of maintaining uniform inspection, the use of instruction manuals in conjunction with the specifications outlined in construction contracts is recommended. The recent survey of pipe line ruptures made for Sub-Committee 8 reveals that some obvious, yet pertinent, points should be emphasized to the inspectors.

On highly stressed lines, scratches and gouges that cause stress concentrations should be eliminated. The welding of braces to the line should be kept to a minimum and only put on after being carefully designed. The design of side connections with their supports and kick blocks should be carefully made and installed correctly. It takes both design and inspection to solve these problems and build both a safe and reliable pipe line.

Acknowledgment

This discussion was presented at the AGA Gas Supply, Transmission, and Storage Conference, 1954. * * *

PIPE LINE COMMUNICATION & CONTROL

Float-Charged Battery Operation For Continuous Station Power

Lee Elmore

Here's what to consider in way of engineering, cost, and maintenance aspects

FLOAT-CHARGED BATTERY banks provide a simple and reliable method of furnishing continuous station power for operating communication and control equipment. Battery operation of stations is an old technique, proved by years of widespread service in the telephone industry for operation of exchange offices, long distance repeater stations, and more recently the transcontinental microwave relay system. Pipe lines and utilities have used batteries for signaling and operation of vital switchgear and supervisory control equipment at remote locations where power is unreliable. Plans were recently announced for the first pipe line microwave system employing float-charged batteries instead of stand-by engine generators *(see page D-38, August, 1955, The Petroleum Engineer)*. Battery operation is now more practical than ever for pipe line communication and control equipment as a result of recent improvements such as mag-amp regulated battery chargers, new materials and types of battery construction, and the design of equipment for low-voltage plate supplies and d-c filaments.

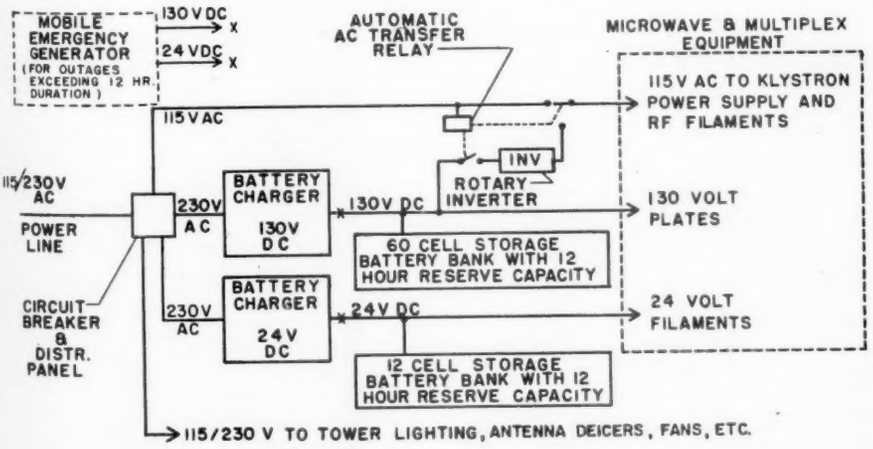
Choice of Power System

The provision of emergency power, like most engineering decisions, is a matter of practical economics and operational requirements. The choice of power supply systems depends largely on the desired degree of reliability, permissible outage time, maintenance program, and amortized cost considerations. Facilities located in cities where the primary power service seldom fails may not justify any stand-by power provision. At remote locations, however, where power service is more subject to outage, emergency power service is required if station operation is vital.

If a short outage can be tolerated, stand-by engine generators with automatic line-transfer panels are a logical method of powering. Stand-by generators may utilize gasoline, LPG, or diesel engines. Primary power failure generally requires an outage of 30 sec to several minutes to give the engine time to start and bring the generator up to proper voltage and frequency. The chief drawback of engine generators has been the danger of malfunction in line-transfer process or failure to start. Recent improvements in equipment and the provision of automatic or remotely controlled exercising have greatly reduced such failures.

When uninterrupted operation is required for control purposes, reliable communication, or transmission of essential data, a continuous power system must be employed. One recently developed power plant for uninterrupted a-c service consists of a motor-alternator-engine set, which incorporates a flywheel to maintain alternator speed during engine starting and a magnetic clutch to couple the engine to the alternator, so that only a slight dip in voltage and frequency occurs during the starting period. This flywheel generator is a practical and economical means of providing uninterrupted a-c power.

A second method of continuous a-c powering is the use of an alternator that is mechanically coupled to an a-c motor and a d-c motor. During normal operation, the line-powered a-c motor drives the alternator and the d-c motor serves as a generator to charge a storage battery bank. When primary power fails, the d-c motor fed by the storage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24 V DC
AUTOMATIC AC TRANSFER RELAY
MICROWAVE & MULTIPLEX EQUIPMENT
115 V AC TO KLYSTRON POWER SUPPLY AND RF FILAMENTS
115 V AC
INV
ROTARY INVERTER
115/230 V AC POWER LINE
230 V AC
BATTERY CHARGER 130 V DC
130 V DC
130 VOLT PLATES
60 CELL STORAGE BATTERY BANK WITH 12 HOUR RESERVE CAPACITY
CIRCUIT BREAKER & DISTR. PANEL
230 V AC
BATTERY CHARGER 24 V DC
24 V DC
24 VOLT FILAMENTS
12 CELL STORAGE BATTERY BANK WITH 12 HOUR RESERVE CAPACITY
115/230 V TO TOWER LIGHTING, ANTENNA DEICERS, FANS, ETC.

FIG. 1. Station battery block diagram.

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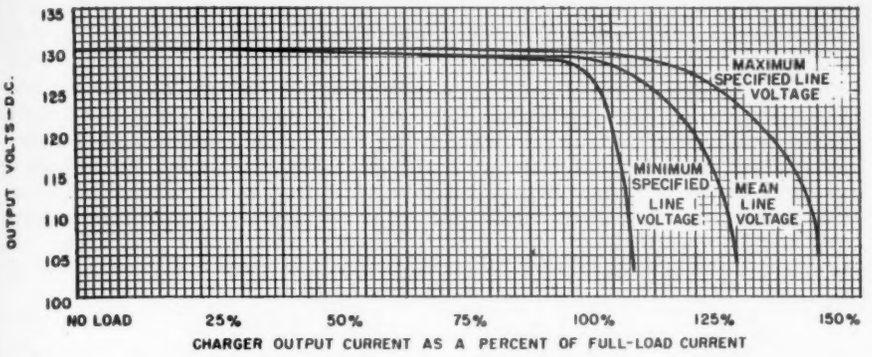
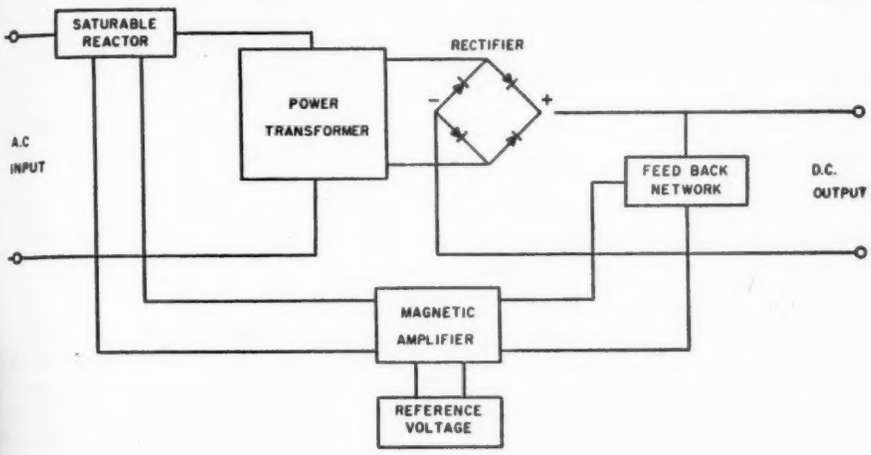


◆ FIG. 2. Regulation curve of a mag-amp controlled 60-cell battery charger.



◆ FIG. 3. Simplified schematic diagram of a mag-amp controlled battery charger.

batteries instantly assumes drive to keep the alternator operating without pause. For sustained outages beyond the capacity of the batteries, an external engine generator may be cut in by an automatic timer to supply d-c to the battery bank to continue operation. Restoration of power line service causes the power plant to revert to normal a-c motor-alternator operation.

Float-Charging Techniques

The most common method of providing uninterrupted power is the float-charged battery technique. Float-charged storage batteries are continuously connected in parallel with the d-c equipment load and a constant-potential battery charger.

The battery charger normally furnishes the current requirements of the load plus a trickle charge that maintains the battery at full voltage. Failure of the primary power source will cause the storage battery bank to instantaneously assume the load and deliver its stored energy to power the equipment. The ampere-hour capacity of the battery bank is selected to provide reserve for the desired period of battery operation. When primary power service is restored, the charger will resume the load and simultaneously recharge the batteries within a period approximately equal to the discharge period.

The float-charged battery system differs widely from the system-governed charge method employed in automobile and engine-generator starting systems. Automobile batteries operate over a wide range of continuously varying charge and discharge conditions. Overcharge and undercharge cause battery gassing and water loss. The poor service conditions of automobile storage batteries limit service life to approximately 2 years. In the float-charge method, by contrast, the constant potential charge produces extended battery life and low maintenance costs. Service life of telephone-type storage batteries in float-charge operation averages 8, 14, and 20 years for three standard types of battery construction.

Station Battery Operation

The operation of a float-charged battery power system can be visualized by reference to the station battery block diagram in Fig. 1. The system described is that planned for the Continental-Sinclair microwave stations, but the technique would be identical for powering an installation of control apparatus or other electronic equipment.

The rectifier-type battery chargers operate from a single-phase 115/230-v primary power line. The 130-v charger supplies the d-c plate voltage to the equipment and trickle charges a 60-cell storage battery bank. The 24-v charger supplies the d-c filament and relay voltages to the equipment and trickle charges a 12-cell storage battery bank. A rotary inverter operates off the 130-v battery bus to supply 115-v a-c as required for special circuits during power line outage. An automatic a-c transfer relay connects the inverter into service almost instantaneously in event of line failure or low voltage, and the filament heat and filter capacitors in the klystron supply cushion the slight break in a-c voltage. There is no interruption or fluctuation of d-c voltages to the equipment when the line fails.

The battery banks are designed to provide a 12-hour reserve capacity for station operation. At the end of the 12-hour discharge period, the battery voltage will have dropped to 1.75 v per cell (105 v for the 60-cell bank and 21-v for the 12-cell bank). The chargers are selected with ample reserve capacity to furnish the load and simultaneously recharge the batteries within 12 hr to full charge of 2.15 v per cell (129 v and 25.8 v for the 60-cell and 12-cell banks).

In event of a sustained power line outage, trailer-mounted engine generators are available to operate the stations until power can be restored. These mobile generators consist of a pair of d-c generators flexibly coupled to a propane-driven engine.

The d-c outputs of the engine generators by-pass the chargers and feed directly into the 130-v and 24-v bus through a four-pole, double-throw load transfer switch, thus providing complete back-up for failure of line or chargers. A spare 130-v d-c/115-v a-c inverter on the trailer may be used to furnish stand-by for the rotary inverter or to furnish emergency lighting voltage.

Chargers

The chargers are automatic, constant-potential battery chargers employing selenium rectifier stacks and magnetic-amplifier regulators. The operating characteristic of a typical 60-cell charger is shown in the regulation curve of Fig. 2. The regulation from no-load to full-load is seen to be essentially flat up to the rapid fall-off action

TABLE 1. Typical battery capacity for various discharge rates.
(Expressed as per cent of 8-hr rate. Minimum 1.75 v per cell.)

Discharge Period	24 hr	12 hr	8 hr	3 hr	1 hr	1 min
Per cent amperes	42	72	100	200	400	1110
Per cent ampere-hours	125	110	100	75	50	.2

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beyond 100 per cent rating. This current limiting action is designed to protect the chargers against heavy overload.

The efficiency of a rectifier-type charger is approximately 75 per cent over the normal operating range. The power factor is approximately 0.6. These factors must be taken into account in planning the building wiring and exhaust fan capacity for the battery room.

The mag-amp control circuit stabilizes the d-c output voltage within ± 1 per cent under line voltage variation of ± 10 per cent. Stabilization is also within ± 1 per cent for line frequency variations of ± 5 per cent.

The selenium rectifiers employed have demonstrated operation of 5 to 8 years in continuous service. Aging of the selenium rectifiers is automatically compensated for by the magnetic amplifier unit.

A simplified schematic diagram of a 60-cell battery charger is shown in Fig. 3. The magnetic amplifier compares the d-c output voltage from the feedback network with a reference voltage source. The difference, or error voltage, causes the magnetic amplifier to supply a d-c current to the control winding of the saturable reactor.

Any variation in output voltage varies the impedance of the saturable reactor and consequently the voltage into the power transformer, thus stabilizing the output voltage. Since the battery is across the feedback network, any change in battery voltage causes the magnetic amplifier to control the charger output accordingly to maintain constant potential.

A stable reference voltage is obtained from a standard, cold cathode voltage-regulator tube. Although this non-filament tube should last for several years, a second regulator tube parallels the voltage regulator tube for stand-by. Failure of the first tube will cause the second tube to fire and function as the voltage reference.

Filtering of the rectified output of the selenium bridge is provided by a heavy series choke and the shunt capacity of the battery banks, which is in the order of 30,000 to 80,000 microfarads. This high capacity and the extremely low internal resistance of the battery bank provide excellent filtering and isolation against noise or hum. The use of a three-phase power source when available would raise the ripple frequency and permit use of a smaller series choke.

Battery chargers are normally furnished with an overcharge switch for equalizing charges, a power-failure relay to isolate battery from charger, meters and controls, and fuse or circuit-breaker protection. An additional relay in series with each charger output is employed to provide a no-charge indication for remote alarm indication of line or charger failure. A line failure or low-voltage condition is separately indicated by the a-c transfer relay associated with the inverter, so that charger failure can be separately recognized from the alarm indications.

Battery Banks

Storage batteries employed in float-charged installations may be lead-acid type or alkaline type, the latter comprised of nickel-iron "Edison cells" or the more recent and improved nickel-cadmium alkaline batteries. Since lead-acid types are most common and economical in commercial service, the following material covers only lead-antimony acid batteries.

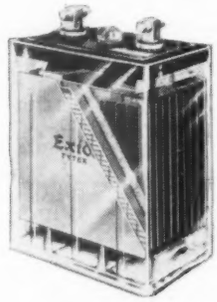

FIG. 4. Typical lead-acid cell of sealed-glass-jar type used in 60-cell and 12-cell battery banks.

A typical sealed-glass jar battery cell is illustrated in Fig. 4. The nominal

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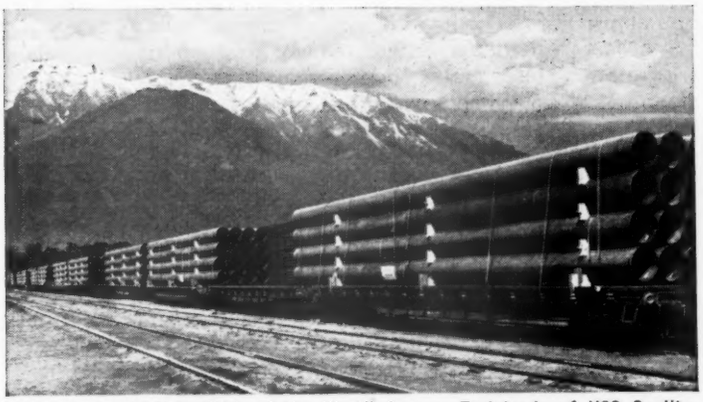

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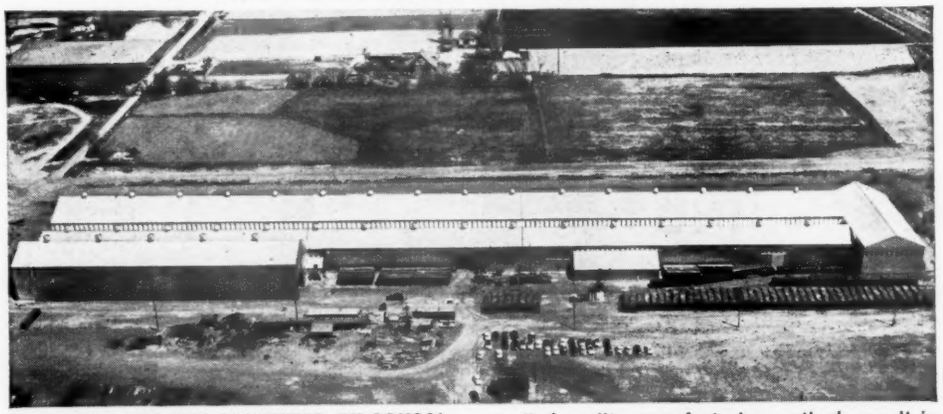

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voltage of such a lead-acid cell is 2.1 v. In float-charged operation, an additional charge of .05 v is employed to compensate for the small internal loss in each cell. Cells are connected in series to obtain the required d-c voltages. Sixty-cell batteries are common for standard, nominal 130-v d-c equipment such as switchgear, telephone apparatus, and, more recently, communication and control equipment.

The storage capacity of a battery is measured by the ampere-hours that can be delivered before the voltage falls to a specified minimum value. This minimum useable voltage is usually specified as 1.75 v per cell, and equipment operating from 60-cell banks is designed to operate with a corresponding minimum of 105 v. The rated ampere-hour capacity of a battery varies with the discharge rate. Table 1 shows the available amperes and ampere-hours expressed as a per cent of the 8-hr discharge rate for various discharge rates. The 8 to 12-hr rates generally represent a practical use of battery capacity in terms of per cent utilization, operational requirements, and cost.

For a given discharge rate and end voltage, the battery capacity in ampere-hours is determined primarily by the number of plates and, to a lesser degree, by the design of separators, battery construction, quantity and specific gravity of electrolyte, temperature, and service condition of the battery.

The discharge characteristic of a storage battery is such that the voltage drops very gradually at first and falls off more rapidly as the end voltage is approached. At a 12-hr discharge rate for example, a 60-cell bank will provide a voltage of 120 v after 1 hr, 115 v after 9 hr, and 105 v after 12 hr.

Under float-charge conditions, as long as the floating voltage is held to proper value (2.15 v per cell for batteries of 1.200 to 1.220 sp gr), the current taken by the battery is automatically corrected by the system without manual adjustments under all conditions including moderate variation in cell temperature. The floating current is normally less than 1 per cent of the 8-hr discharge rate in amperes.

During recharging of the batteries after a line outage, the ampere-hours used during the outage must be replaced. In addition, an over-charge must be provided to compensate for the ampere-hour loss due primarily to gassing. Under typical float-charged service conditions, the ampere-hours required to restore the battery to original charge will be 10 to 15 per cent greater than the discharged ampere-hours.

The effect of low temperature on battery capacity must be considered at remote or unheated installations. A typical battery, which is to be discharged at a 12-hr rate, will have its capacity reduced by 0.54 per cent for every degree of initial electrolyte temperature below 77 F.

At a cell temperature of 50 F for example, the battery capacity would be reduced almost 15 per cent. The cell temperature on float charge will be somewhat above the room ambient temperature, which will in turn be considerably above the outside temperature, as a result of the charger-heat dissipation and building warmth. Strip heaters may be employed to maintain cell temperature during normal operation to assure full battery capacity. When line voltage occurs, the increased activity of the discharging batteries and the heat retention of the building will maintain cell temperatures.

Typical Ratings

The battery and charger ratings for a station can be determined from the load requirements, battery operation time, and minimum equipment voltage. A typical microwave through-relay station has the following load requirement under battery discharge conditions:

130-v battery:

3.4 amp for d-c plate load
7.6 amp for 115-v a-c inverter

11.0 amp total

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At a drop-relay station with 10 multiplex channels, the 130-v load increases to 12.3 amp and the 24-v load increases to approximately 20 amp.

Batteries to furnish these load requirements for a 12-hr period are readily selected from manufacturers' tables or curves based on the number of amperes per positive plate. The ampere rating is a direct function of the number of positive plates. For example, a typical battery with 5 positive plates (a total of 11 positive and negative plates) provides 11.5 amp at the 12-hr rate. This battery satisfies the above through-relay station 130-v load requirement. At the 10-channel, drop-relay station, one more positive plate (6 positives or a 13-plate cell) would be required for the 130-v load, and a heavier battery construction would be required for the 24-v load.

Some installations will include switchgear that pulls a high momentary ampere load. This requirement is computed from the 1-min discharge rate and added to the number of positive plates required for the constant equipment load.

The charger output requirements are shown below for operating a through-relay station employing a float-charged, 60-cell battery and inverter arrangement as shown in Fig. 1.

1. **Normal float-charged operation:**
   Charger output = d-c load + trickle charge
   = 3.4 a + 0.1 a
   = 3.5 a

2. **During power line outage (maximum 12 hr):**
   Charger output = zero
   Battery output = d-c load + inverter load
   = 3.4 a + 7.6 a
   = 11 a × 12 hr
   = 132 amp-hr discharged

3. **During recharge period (maximum 12 hr specified):**
   Charger output = d-c load + amp-hr discharged + amp-hr efficiency factor
   $= 3.4\ a + \left(\frac{132a}{12\ hr}\right)1.15$
   = 16 amp maximum

The 60-cell charger must be rated for at least 16 amp for full recharging during 12 hr. Normally, the charger will operate at 3.5 amp output.

In other applications where a large inverter load is not present and the batteries need not be fully recharged so fast, it is general practice to provide

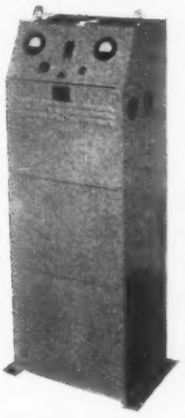


FIG. 5. Typical high-amperage magnetic-amplifier controlled rectifier type battery charger.

charger capacity for the d-c load plus a recharging reserve of 25 to 50 per cent of the 8-hr discharge rate of the battery.

Maintenance

Float-charged battery maintenance is simplified by the action of the constant-potential charger. The maintenance routine consists of a monthly visit to equalize the charge, add water and clean the battery, and log readings.

The equalizing charge is applied by means of a switch on the charger that elevates the voltage to 2.33 per cell (140 v for an 8 to 24-hr period). This charge insures that all plates are restored to a fully charged condition. Shorter equalizing periods would require higher voltages, and 140 v is the usual maximum rated voltage for equipment operation.

Higher operating voltages would require use of counter-emf cells between the battery bus and the equipment load. These CEMF cells were widely used as voltage-regulating devices before the advent of chargers with flat regulation characteristics.

Water must be added to compensate for loss due to decomposition into hydrogen and oxygen, as evidenced by gassing of the cells. Water requirements are minimized by floated operation, which limits overcharging and resultant gassing. With vent plugs in place and proper liquid levels, the amount of water replaced each month should not exceed 0.11 pints per cell for a typical battery.

A periodic log of specific gravity and voltage of each cell is useful for evaluating and extrapolating cell conditions.

Installation

Battery banks, chargers, inverters, and associated electrical apparatus are generally installed in a separate compartment from the electronic equipment. A 6 by 11-ft room such as normally used for engine generators in microwave stations makes an excellent battery room. Batteries are usually mounted on two or three-tier racks. When lead-acid cells are employed, the battery room should be ventilated to exhaust any gasses that might accumulate.

Stand-by Power Cost Comparison

The cost of stand-by power protection is best visualized in over-all perspective as a percentage of the total installed system cost. In comparing battery systems (d-c station operation) with other types of stand-by power plants that require a-c operation of equipment, the elimination of a-c rectifier power supply chassis must be taken into account, both in dollar savings and in elimination of possible failure causes.

In a typical, large microwave relay, the cost of various power stand-by provisions may be compared as follows: The basic microwave system, less power provision, is the same for all three arrangements except for equipment design for a-c or d-c operation as noted. The percentages shown are with respect to the total installed system cost.

1. **Stand-by engine-generator:**
   (a-c operation; short outage during start-up)
   a. Engine generators, automatic line-transfer control panels, starting batteries and fuel tanks 5%
   b. Rectifier power supply chassis 5%
   Approx. 10%

2. **Flywheel-generator system:**
   (a-c operation; uninterrupted power supply)
   a. Flywheel-generator power plants and fuel tanks.....8.5%
   b. Rectifier power supply chassis 5%
   Approx. 13.5%

3. **Float-charged battery system:**
   (d-c operation; continuous power supply)
   a. Batteries (12-hr), chargers, inverters, transfer relays, and allowance for d-c electrical fixtures 12.2%
   b. Mobile, emergency engine generators 1.3%
   Approx. 13.5%

The cost of a float-charged battery system, including mobile units, is seen to be approximately the same as a flywheel-generator system and approximately 3.5 per cent higher than a stand-by engine-generator system. This additional 3.5 per cent is the price paid for eliminating the outage during engine start-up period, eliminating major failure causes much as power supply chassis and engine control panels, and for providing the ultimate in continuity and reliability of power service. *

Now is the time to start thinking about . . .

Winterization of Construction Equipment

Victor A. Woodling

THE nearness of winter is a reminder to prepare for protection of pipe line construction equipment. Preparation is prefaced by a decision to winterize, either for operation or for semi-permanent storage. Heavy equipment is designed with the thought that operation will occur under conditions far from ideal, and those conditions more commonly occur in cold weather.

With forethought and planning, machinery can operate satisfactorily regardless of the intensity of the weather. In winterizing for storage, it should be remembered that for prolonged machine service life there is no substitute for running the machine periodically. For machines that will not receive attention during the winter, however, thorough winterizing service prior to storage will provide the best protection.

Choice of Lubricants

As the temperature becomes lower, lubricants of lower viscosity should be used. At temperatures below freezing, engine crankcase should be filled with SAE 10-W crankcase oils to promote easier cranking and provide adequate circulation during the warm-up periods. In extremely cold climates, it may be necessary to dilute the oil with kerosine so that it will be fluid enough to circulate freely.

Normally, all that is required is a complete change of lube oil and a change of oil filter elements. On older machines, the crankcase should be flushed before adding the new oil. This will remove a lot of accumulated sludge that can hold water during cold weather.

Light grades (No. 1 or No. 0 grade) of ball and roller bearing lubricant are much better for operation in cold weather. Transmission oils, too, must be fluid enough to flow readily at the prevailing temperatures. Below freezing, use the lower viscosity (SAE No. 80) transmission oils. In extremely cold weather, even further thinning of the transmission oil with kerosine may be necessary to promote fluidity.

Considerable drag during starting is created by direct-connected power units such as the front power take-off, and front-mounted cable and hydraulic control units. When the temperature falls, the lubricants or hydraulic oils in these units thicken proportionately. Do not forget to change to lighter weight oils in direct-connected power units. Here again, oil dilution in gear boxes or hydraulic controls should be accomplished with some caution, as there is always the possibility of over-dilution. Use only enough diluent to assist in starting . . . *dilution practices are somewhat like cooking recipes that state, "season to taste."*

In track-type tractors, proper lubrication of the track rollers, idlers, and track-carrier rollers is always very important. In sub-zero weather, it may be necessary to use transmission or crankcase lubricating oil instead of the usual track-roller lubricant. The standard volume compressor is a very good guide to the proper lubricant for track parts. As long as the lubricant can be handled by the volume compressor, it is of sufficient fluidity for rollers, carrier rollers, or idlers.

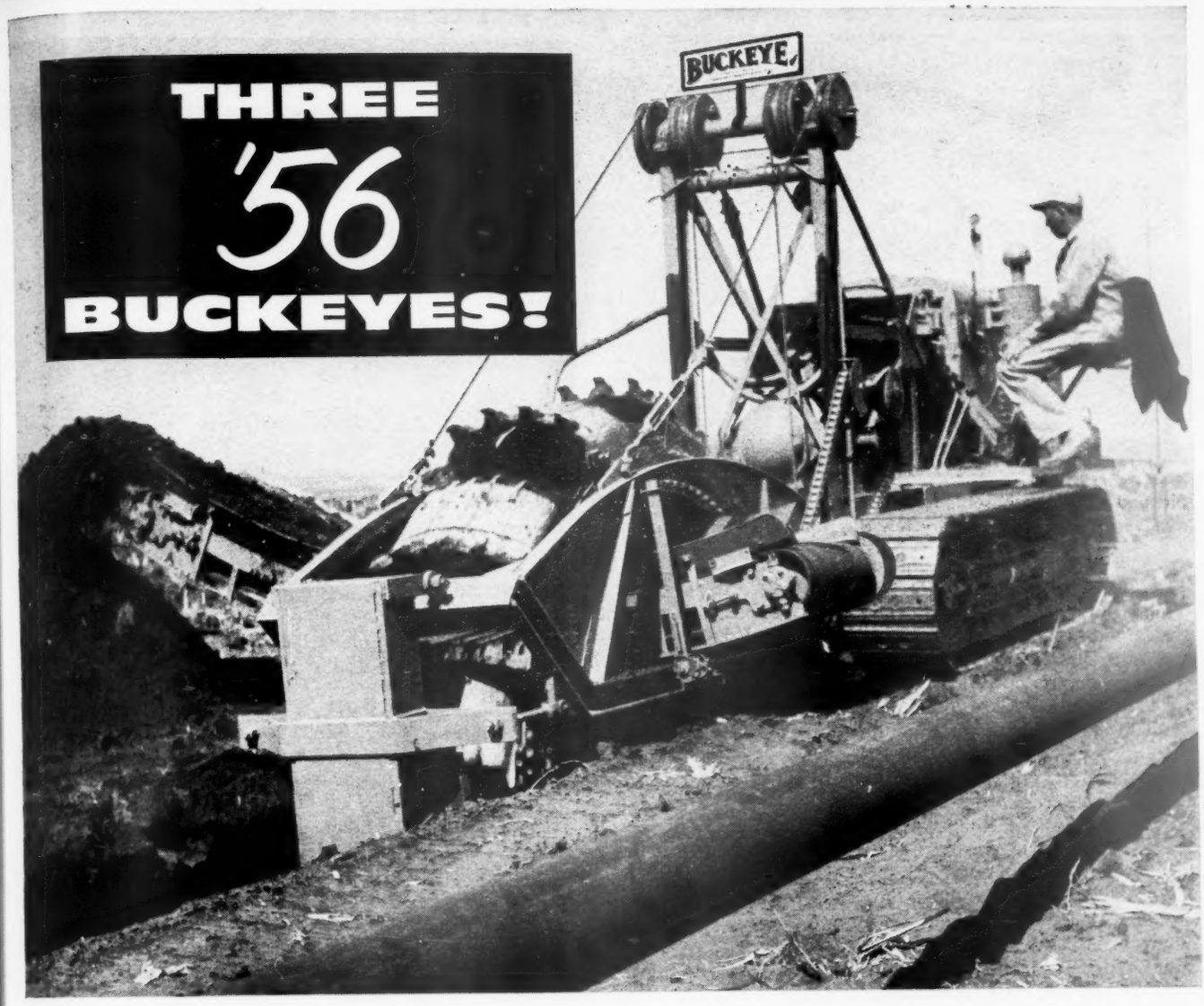
Starting System Care

If both the gasoline starting engine and diesel engine are in good mechanical condition and the precautions regarding lubricants for cold weather operation are observed, there should be little difficulty in starting as the starting engine is fully efficient even in extremely cold weather. To promote longer life during low-temperature operations, avoid overchoking and fast idling speeds. If the starting engine has a two-speed transmission, make full use of the lower speed gears when cranking a cold engine.

The entire electrical system should receive a check-up before cold weather arrives, especially the magneto on the starting engine. More attention should also be given to battery-operated electric starting systems. *Batteries* present a peculiar problem, for as temperatures drop, all batteries — even new ones — begin to lose their efficiency.

Regular battery checks and servicing and changing to recommended lighter engine lubricating oils will help insure maximum starting power with a minimum of frictional resistance. Remember, the electrolyte in a discharged battery is mostly water, so never ex-

With systematic lubrication and maintenance, pipe line machinery will operate satisfactorily in severe weather.



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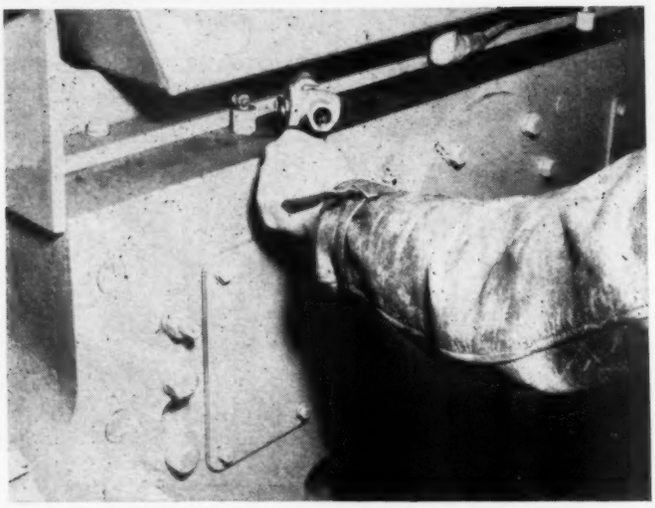


Dirt and moisture will settle to the bottom of fuel tanks. Drain off a small quantity of fuel every few days to keep the tank clean.

Cooling system maintenance becomes increasingly important in cold weather.

pose a discharged battery to freezing temperature as it will most certainly freeze and break.

Those diesel engines that depend solely on electric or air-starting motors for cranking power are sometimes difficult to start without some additional help at temperatures below 50 F.

Either the application of additional internal heat, as provided by glow plugs, or the use of ether starting aids offers very effective assistance in assuring positive starts in cold weather.

Glow plugs, for example, are individual, steel encased, electric-heating elements inserted alongside each capsule-type fuel injection valve and extending into special precombustion chambers. Thirty seconds after the switch is closed, the elements reach a temperature of approximately 1800 F, heating the air in the precombustion chamber and thus aiding the initial ignition of injected fuel.

The ether capsule starting aid is also extremely simple to operate, requires little maintenance, and is inexpensive. Ether starting aids are offered for all tractors and motor graders as well as for engines of the various models, and their installation should be carefully considered for those engines which are to be operated in extremely cold weather.

Cooling System Protection

One of the most important points in preparing for cold weather operation is the protection of the cooling system by the addition of sufficient antifreeze solution. Alcohol-type antifreeze can be used in diesel engines, but because of the higher operating temperatures found in diesel engines, it is advisable to use a permanent-type antifreeze.

The rust inhibitor additive should adequately protect an engine from rust if the antifreeze solution is used in accordance with the manufacturer's published recommendations. Since the antifreeze solution has a lower viscosity than water, it will leak where water will not. Therefore, the cooling system should be checked for possible leaks prior to filling with antifreeze solution.

Some operators prefer to use only water (without antifreeze), and drain both the radiator and cylinder block at the end of each day's operation. **This is a poor practice for several reasons:**

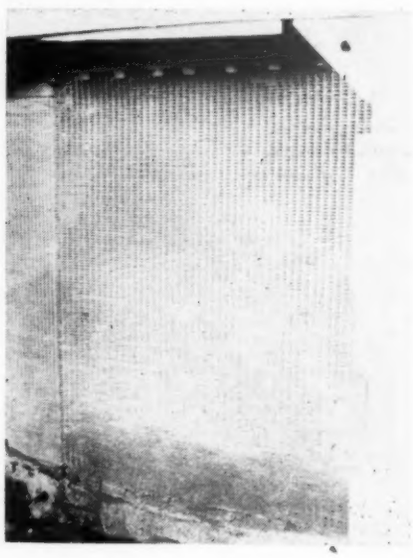
(1) Failure to drain the complete system just one time during freezing weather can cause considerable engine damage.

(2) The engine is probably operated without a rust inhibitor.

(3) Each time the cooling system is filled, additional scale-forming minerals are introduced.

Remember to check the fan belt, which is so often neglected—it's a very important part of the cooling system. Stretched and frayed from the summer's heat, a tired fan belt may turn its last turn on a zero day.

Radiator cones packed with mud cause cooling problems. A few minutes spent in clearing is well repaid.



Fuel System Maintenance

While considering the possible damage caused by water freezing in a diesel engine, it is well to remember that besides the cooling system there is another place the water really causes trouble in cold weather—the fuel system.

The best way to overcome this problem is to eliminate water at its source by preventing condensation within the fuel tank. In both cold and warm weather, it is best to completely fill the fuel tank at the end of each day's run. This drives out the moisture-laden air from the tank and prevents airborne moisture from condensing and entering the fuel system.

Much of the water can be eliminated by draining off a small amount of fuel each morning. During cold weather, drain the fuel filter housing at regular intervals to prevent accumulated water from freezing and possibly cracking the housing.

Another point to consider when operating in cold weather is the type of fuel. For sub-zero operation, a fuel having a low pour point is needed to insure proper flow from the fuel tank to the fuel transfer pump. Such fuels are often called "winter grade" and are available in most areas. They should be used in preference to the higher pour-point fuel suitable for summer operations.

Air Cleaner

The air cleaner should receive careful attention at all times, but the approach of cold weather makes this care even more important. As the temperature drops, the oil in the air-cleaner cup may have to be changed to SAE

10 in order to be carried up into the screens and perform its job of removing dust from the air entering the engine. Do not dilute air cleaner oil with kerosine.

When the tractor or motor grader is operated in blowing snow, the air cleaner or its inlet may plug rapidly. In such conditions, the pre-cleaner opening must be checked frequently to assure efficient engine operation. Many operators have found air-intake extension pipes quite helpful in keeping snow out of the air cleaner. Don't forget the starting engine air cleaner. It requires its own share of maintenance, winter or summer.

Tracks

Tracks, track rollers, and carrier rollers also require some additional attention when the cold winds blow. Snow frequently packs between the rails of the tracks, causing excessively tight tracks. The best solution for this condition is the installation of special snow track grousers. These plates have holes in their centers that eliminate packing.

Track hardware is subjected to tremendous stresses if a tractor becomes frozen in mud. Never park a machine where there is danger of freezing the tracks to the ground. A simple log berth for the machine will prevent freezing of tracks and will relieve an operator of a lot of work when the machine is to be moved.

Frozen mud around the track rollers and carrier rollers will lock them tightly. If a machine is run any distance with frozen rollers, the track rails rubbing over the rollers will wear flat spots on them, rendering the roller practically uesless.

A little time spent cleaning the track assemblies prior to parking the tractor will pay dividends in lowered repair costs. This is a dirty task, but it's much easier than freeing a frozen roller.

Dry Compartments

The "dry" compartments throughout a machine should be kept that way especially during winter operations. Replace missing drain plugs and gaskets in the flywheel clutch and steering clutch enclosures. When operating in mud or water, these compartments can accumulate debris and mud that may freeze and cause serious damage to the working parts.

Storage

Construction machines that are to be put in semi-permanent storage for the winter require special preparation before being stored.

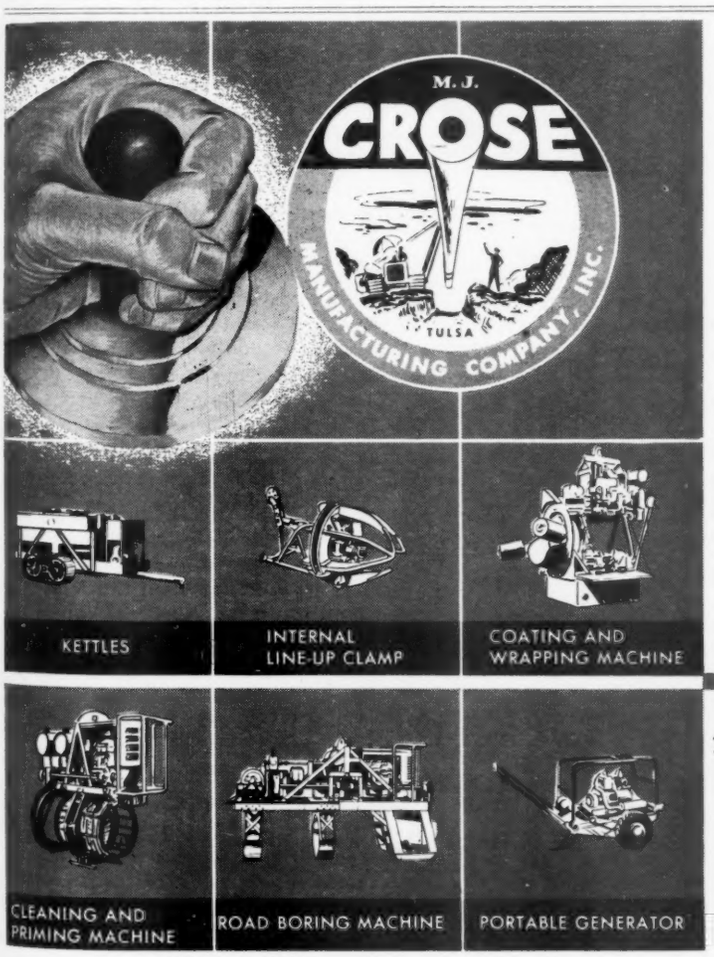
The great destroyer of stored equipment is rust, and preventing its formation is the most important single item in winter storage of machines.

A complete lubrication of the machine before storing it for the winter is very good insurance. Clean the equipment completely before it is placed in storage and spot paint the exposed metal surfaces to protect them from rust. Covers and gaskets should be checked to be sure they are tight and sealing properly. A coating of grease applied to cables, sheaves, blades, and cutting edges will ward off the attacks of rust and corrosion.

The "insides" of the machine being stored must also be protected during the period of idleness. But, to obtain the longest life, the machine should not be left entirely "idle." It is best to run the diesel engine and starting engine once a week and, on track-type tractors, to run the machine forward and backwards a short distance to redistribute the lubricant on the bearings, gears, and final-drive seals thus preventing them from sticking.

If it is not convenient to run the engines, the cylinders can be kept rust-free by adding approximately a cup of oil to each cylinder at the beginning of the storage period. Once a month, turn the engine over to redistribute oil on the cylinder walls.

The starting engine should be similarly protected by adding approximately two tablespoonfuls of oil in each



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cylinder. Then, about once a month, crank it slowly to redistribute the oil.

Another place where rust can form is in the cooling system. If properly protected with a good permanent-type antifreeze solution, the cooling system is safe from freezing and from rust because nearly all good antifreeze solutions contain a rust inhibitor.

The addition of antifreeze is the best way to protect a stored engine because it permits the engine to be run at weekly intervals with a minimum of preparation. The cooling system is thus protected against rust and the various gaskets through the engine are protected from drying out (which could lead to leaks at a later time).

If antifreeze is not used, the inner surfaces of the cooling system will be reasonably well protected if a soluble oil-type rust inhibitor was used in the cooling system for some time prior to storage.

If this has not been done during the operating season, **soluble oil-type rust inhibitor should at least be added during the last week of operation before draining for storage.** This allows the film of oil to spread throughout the inner surfaces of the cooling system and provide a coating of oil.

Internal rust damage is often the result of improper service before storage. Moisture may collect in gear compartments and if left there can cause gears and bearings to rust. Before storing a machine, the crankcase, transmission case, and final-drive housings and the gear cases of mounted attachments should be drained while the machine is still warm. Draining right after operation provides the best chance of removing any moisture that may have been present in the oil due to condensation. The various compartments should be cleaned and filled with new oil. To properly distribute the new oil, the machine and all its equipment should be run for a short time—a procedure, which as mentioned above, should be repeated regularly during the storage period.

Don't overlook the fuel tank. It may contain some water. Before storage, drain off a quantity of fuel from the sediment drain. If storage conditions permit, keep the tank full of fuel. Rust is not likely to form inside a full tank.

If your equipment includes some rubber-tired units, it is best to block up the vehicle and reduce the air pressure to 50 per cent of that recommended as normal operating pressure. If blocking is not practical, make sure that correct pressure is maintained throughout the storage period.

Before extended storage, clean all tire surfaces of dirt and lubricants as considerable tire deterioration is the direct result of oil and grease on the surfaces. After cleaning, carefully inspect tire surfaces. Breaks or cuts should be repaired, especially those in which the underlayers of fabric are exposed. Moisture may be absorbed through these breaks and cause rapid deterioration during storage.

The reminders mentioned here are necessarily general. Most manufacturers of pipe line construction equipment detail specific cold weather and storage instructions in the instruction books that accompany the machine. The importance of reviewing these recommendations can't be over-emphasized. The time spent has often been proved most profitable. * * *

The Author

An electrical engineering graduate of Purdue University, Victor A. Woodling joined Caterpillar Tractor Company in 1946 following four and one-half years in the armed forces. Since 1946 he has been a college graduate trainee, a service development division trainee, supervisor of service training, and dealer publications supervisor and is presently service development manager.

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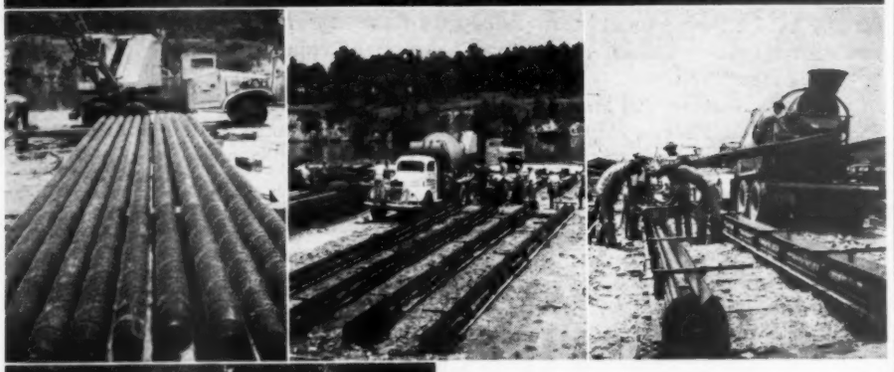

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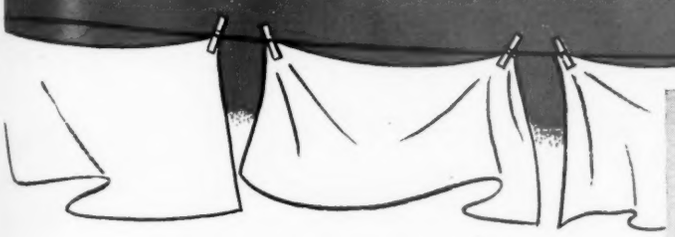

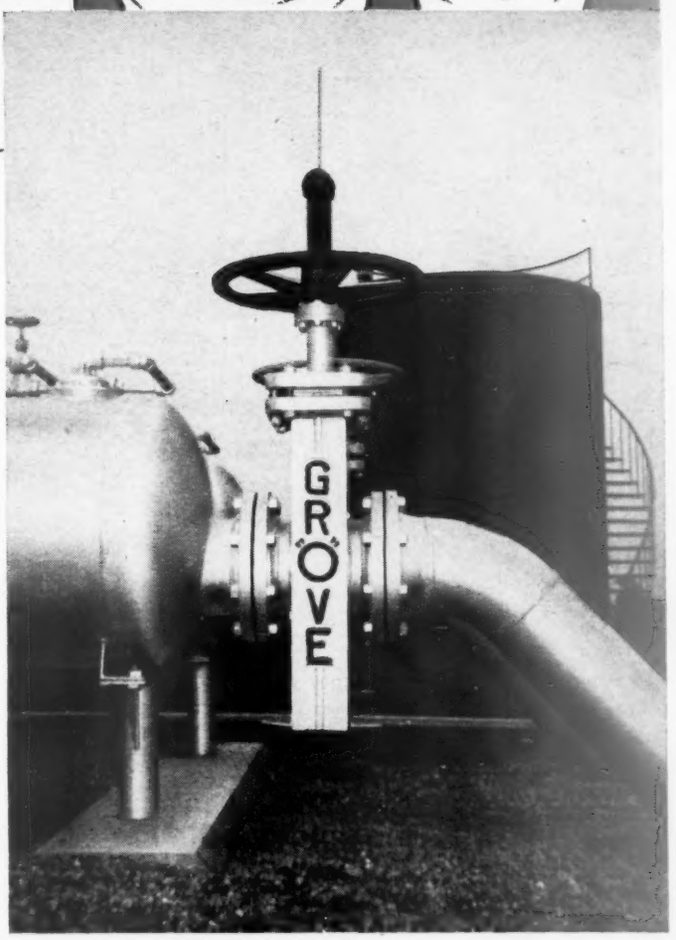

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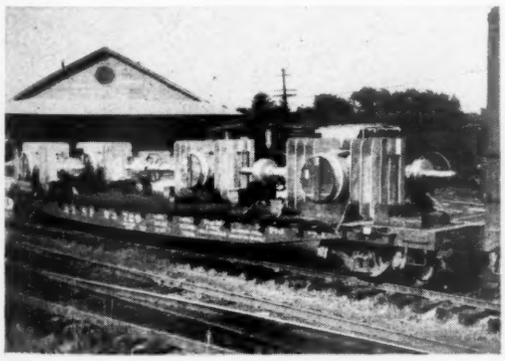

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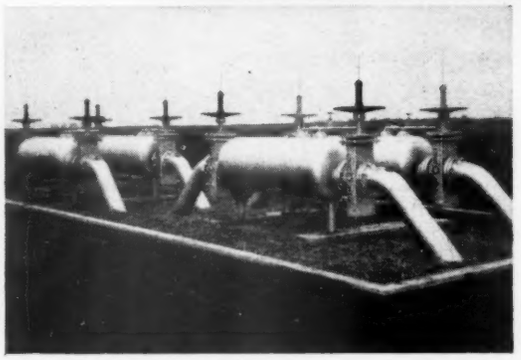

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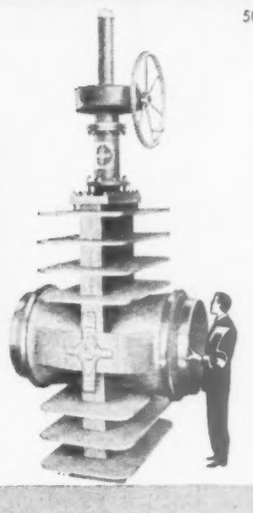

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Two hydraulic cutterhead dredges complete trench across Arkansas River for two 24-in. gas pipe lines. Laying barge is at left of picture.

P 615.371

River Crossing Engineering Practices

Leo M. Odom
Pyburn and Odom, Consulting Engineers, Baton Rouge, Louisiana

THE SUCCESSFUL AND ECONOMICAL construction of river crossings in common with other large construction projects requires both engineers and construction contractors.

The engineer is educated in mathematics and physical sciences and trained in certain methods of approach to problem-solution based on his scientific background. On the other hand, the construction contractor is usually characterized by an approach to problems which is based on practical experience in handling men and the materials and equipment of construction. It is the engineer's job to decide how, where, and with what materials a job is to be built and to see to it that his specifications are followed out, and the construction man's job to build it.

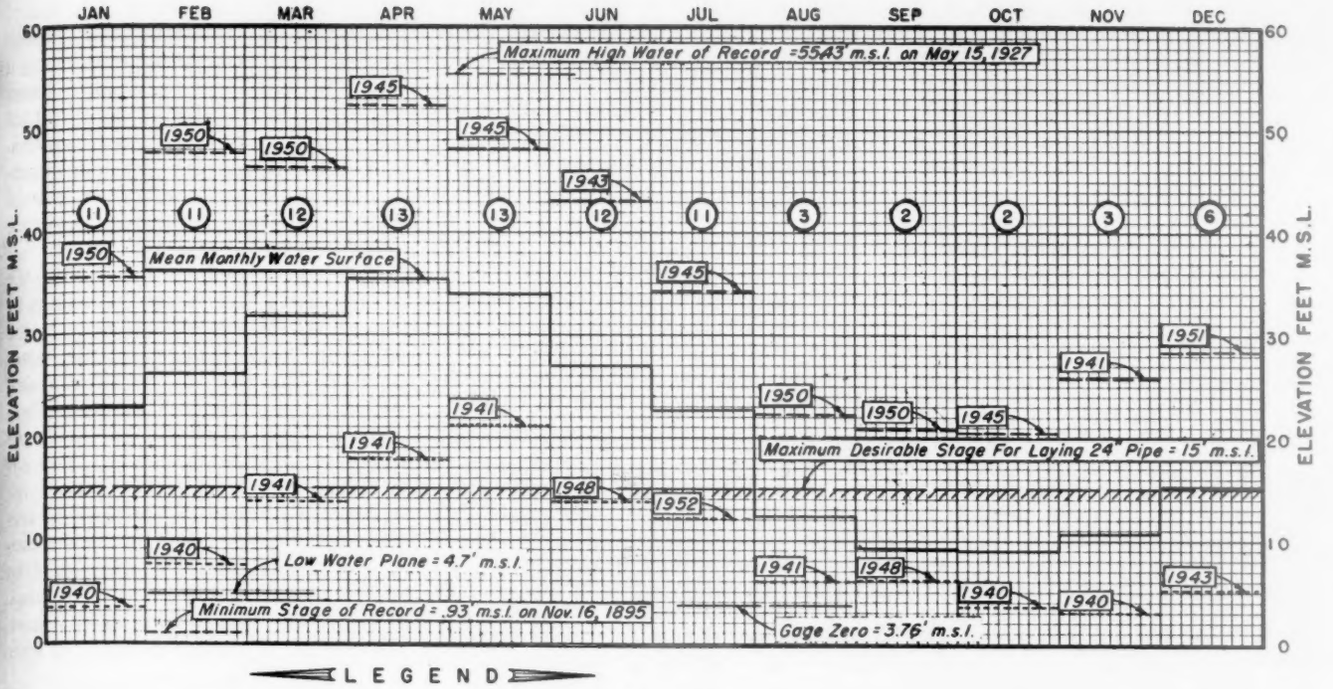
Pipelining has progressed from small beginnings during the latter part of the nineteenth century until today it is one of the major transportation media of the world. The lines have become larger and pressures greater and their uninterrupted service has become increasingly important. Because a river crossing is so difficult to repair and so vulnerable to damage, its design and construction must be given proportionately more care than the rest of the line.

Rivers differ greatly in their characteristics and very few general statements can be made which would be applicable to all rivers. There are rivers with rocky beds, rivers which are subject to sudden severe floods, rivers which meander in silty plains, rivers within which the water is acid or alkaline in character, to mention only a few of the peculiarities which have to be investigated in the design of a pipe line crossing.

The two types of crossing used for rivers in this country are bridges and underwater lines. The choice between these two types is based upon comparisons of costs and time required for construction. In the great majority of cases, underwater crossings are more economical and comparatively few bridges have been constructed. For this reason and because of the limited space available, this discussion will be restricted to a brief analysis of the factors to be considered in underwater pipe line river crossings.

The problem of crossing a major river with a large pipe will be subdivided into the following phases for the purpose of this discussion:

1. **Selection of the site**
2. **Design considerations**
3. **Installation procedure**
4. **Selection of working season**
5. **Inspection and testing**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Maximum High Water of Record =55.43' m.s.l. on May 15, 1927
Mean Monthly Water Surface
Maximum Desirable Stage For Laying 24" Pipe = 15' m.s.l.
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Minimum Stage of Record = .93' m.s.l. on Nov. 16, 1895
Gage Zero = 3.76' m.s.l.
LEGEND
Mean Monthly Water Surface For Period 1940–1952.
Maximum Mean Monthly Water Surface For Any One Month During Period.
Minimum Mean Monthly Water Surface For Any One Month During Period.
Number Of Months In Period With Mean Monthly Stages Above 15' M.S.L.
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MEAN MONTHLY WATER SURFACE ELEVATIONS
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Graph of information from gage records for determination of working season.

Pipe laying operation in main channel, Mississippi River near Memphis. Laying 2 pipes in one trench.

● **Selection of the Site.** Rivers not only differ from each other but the same river varies greatly from one place to another. While it is conceivably possible to construct a successful river crossing at any location, it is essential from a practical standpoint to exercise great care in the selection of the site for the crossing in order to be able to build it within the limits of available time and money. The overall alignment of the pipe line must, of course, be taken into consideration in the selection of the site but when rivers the size and character of the Mississippi are to be crossed, changes in alignment are justified in order to miss reaches that exhibit extreme instability.

In making the study for selection of the site, it is first necessary to compile the history, geology, and hydrology of the stretch of river within which the crossing could be economically made. Basic data are usually obtainable from the records available in the files of the U. S. Army Engineers and other federal and state agencies. This study makes possible a fairly close approximation of the location. It is then necessary to make an accurate up-to-date survey of the river noting caving banks, sand bars, etc., so as to arrive exactly at the best location within the selected reach.

● **Design Considerations.** In order to lay a pipe on the bottom of a stream and to have it remain in service after it

is laid, the line must be capable of resisting the actions of a number of destructive agencies. The effects of buoyancy, stream currents, stream turbulence, scour and fill of the stream bed, bank recession, debris and sand movement, temperature changes, anchoring of boats, dredging, corrosion, corrasion and attack by marine organisms must all be taken into consideration in attacking the problem of the design of an underwater stream crossing.

The only practical recourse to protect the pipe against some of these actions is the entrenchment of the pipe into the bed and banks of the river. For streams flowing in channels composed of stone, it is only necessary to blast a trench across the stream deep enough to cover the pipe. This trench should have a smooth bottom and be laid out so that the pipe can be fitted to it with as few bends as practicable.

Entrenchment in alluvial rivers requires a great deal more consideration. Bank and bed changes are constantly occurring in such streams to more or less extent. Even in reaches where the banks appear to be quite stable, a series of cross sections taken during a complete flood cycle will show that the elevation of the bed is quite variable.

Besides the requirement of burying the pipe to prevent damage from currents, dragging anchors, corrasion, etc., the pipe must be buried deeply enough so that scour will not expose it and it must be entrenched into the banks enough so that bank movement will not disturb it or uncover it. The determination of the correct amount of entrenchment for the crossing of an alluvial river is the essence of the problem once the site has been selected.

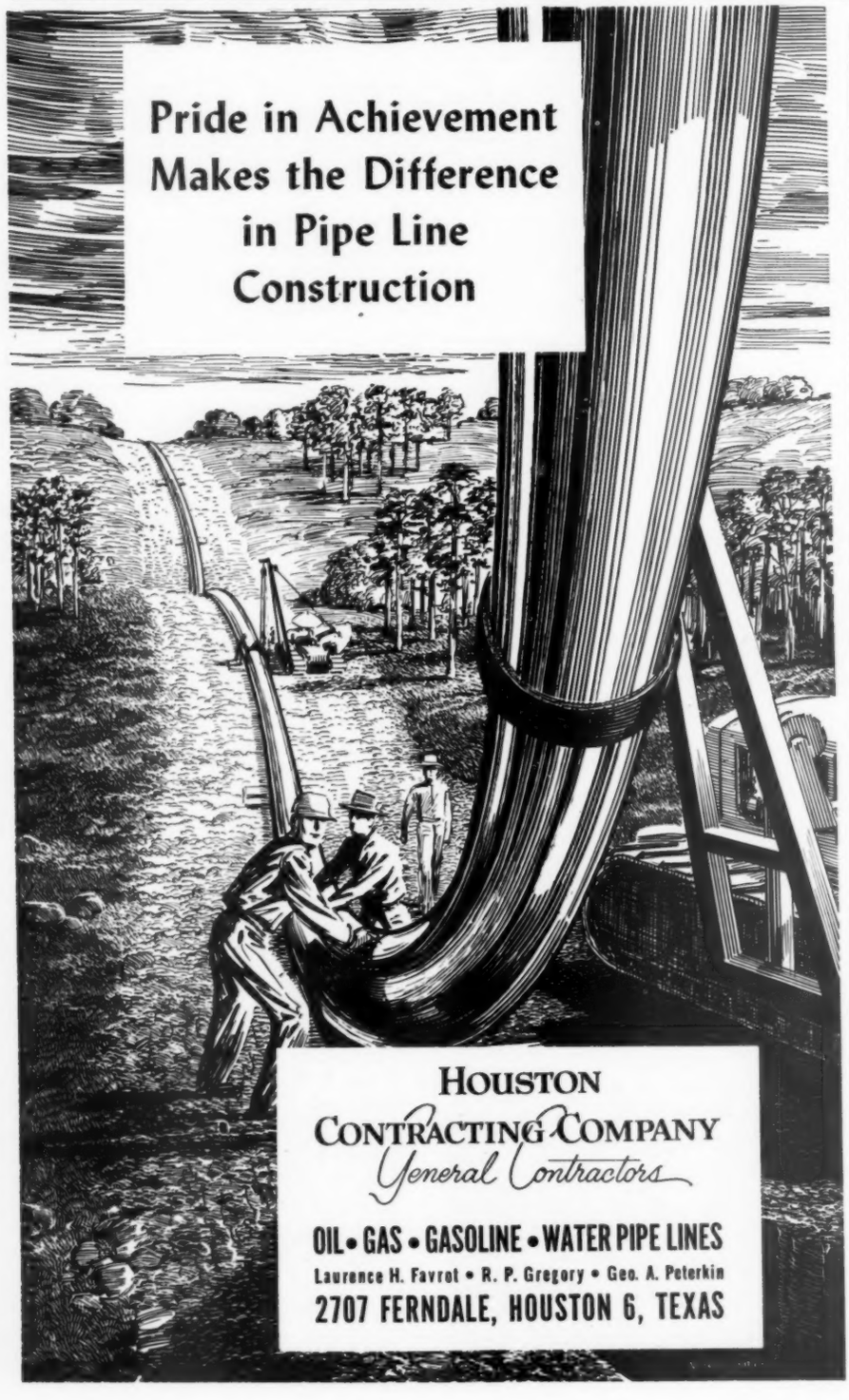
The best method for entrenching the pipe across a large alluvial stream is by means of hydraulic dredging in the bed and in the banks up to the water surface, the trench to be excavated prior to the placing of the pipe. *There is little or no advantage in bowing the pipe up or down stream if it is entrenched and it is far simpler to dredge the trench straight across the river.* It is not usually necessary to fill the trenches between banks since the river will take care of that in short order. The bank trenches should be backfilled to restore the original alignment of the bank lines if it is practicable to do so.

The steel from which the underwater pipe line is made should have as much flexibility as is consistent with strength and weldability requirements. For land lines it has become the practice to raise the yield point by expansion of the pipe so as to permit less wall thickness. Underwater crossings are more inaccessible and a break in such a crossing is many times as expensive to repair as one in a line on land. *It is, therefore, very important to specify carefully the steel to be used and to keep working stresses lower than in land pipe.*

In the design of large pipe lines, the wall thickness required to take care of the pressure is always less than would be necessary to overcome the buoyancy of the pipe. In order to place the pipe, it is therefore necessary to furnish weight in excess of that required for overcoming the buoyancy as computed on the basis of its displacement of fresh water. Enough extra weight must be added to cause the pipe to lay in the trench at the desired location and go to the bottom of the trench even if it is partially filled with soft mud.

It has been found that for large pipes across the Mississippi River, the addition of weight so as to furnish a total weight in air equivalent to about 1.3 times that of the volume of water displaced by the pipe, plus the weighting material, will provide for good placing and insure that the pipe remains in place until the trench is backfilled. Small pipes are frequently laid directly on the bottom without trenching because of the relative expense involved. Such lines are usually weighted very heavily so as to resist movement due to currents.

Weighting can be accomplished by adding thickness to the pipe; by the at-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tachment of concrete or steel weights (called clamps); or by continuous coatings. The requirement for retention of maximum flexibility should be considered in the choice of a weighting method and material. It is also important, particularly during the laying process, that the area and length of pipe exposed to the current be as small and as smooth as possible. Each method of weighting still has its advocates, but the continuous coating using heavy-aggregate concrete for the coating is now most commonly used. The use of barite aggregate has been found to provide a strong, durable concrete weighing consistently 185-190 lb per cu ft. Coating methods are such that the surface is left very smooth and the coating adheres to pipe quite tenaciously, serving to protect the corrosion coating during handling. As of the present time it also provides the cheapest method of securing additional weight.

● **Installation Procedure.** The method of installation to be used is usually either pulling or placing from a laying barge. The laying barge method is slower and more expensive but is usually preferred on large rivers particularly where there are traffic and currents. The main problems in installation are to get a good bed for the pipe and to keep from overstressing it or damaging it in laying. Sagbends and overbends should be bent on the job to fit the trench as actually dug. In many cases it will be found feasible to lay the pipe without permanently bent sags, which is advantageous from the standpoint of laying.

In order to get a good installation for a pipe across a large river, it is very necessary that the contractor be experienced on river work and that he have adequate proper equipment.

Corrosion protection is accomplished by doping and wrapping and cathodic protection similar to that provided on land lines. It is necessary to exercise extreme care in corrosion control of a crossing because of its future inaccessibility. A careful check of the chemical qualities of the river water at all stages should be made so as to determine if special precautions are necessary.

● **Selection of Working Season.** On all rivers, there are certain months in the year during which it is feasible to work and others when the best efforts are likely to fail. There are very few rivers for which it can be guaranteed that a trench can be opened up and a pipe can be laid every year. Some years, unpredictable flash floods will occur that will halt dredging, fill trenches or break the pipe while it is being laid. On the other hand, a great deal of misery can be avoided by the study of hydrographs of the river for a number of years and the selection of that period of the year during which chances of successful work are best.

● **Inspection and Testing.** The best laid plans of engineers are worthless unless they are followed. The only way to insure compliance with specification is to inspect the work carefully during construction and to test it when it is completed.

The construction of a dependable river crossing requires that the welding and corrosion inspection should be of very high order. A great many other factors that are involved in dredging the trench to proper grade and alignment and laying the pipe should be checked continually during progress.

As for testing the line, the usual practice is to test the joints separately at pressures in excess of working pressure before welding them into the line. After the line is laid, it is customary to run a pig through and to give the crossing a test for several hours at about 125 per cent of working pressure before backfilling. The testing is done either with gas, air, or water.

Acknowledgment

This article taken from a discussion presented at the American Gas Association Gas Supply, Transmission and Storage Conference, May, 1955, Pittsburgh, Pennsylvania. * * *

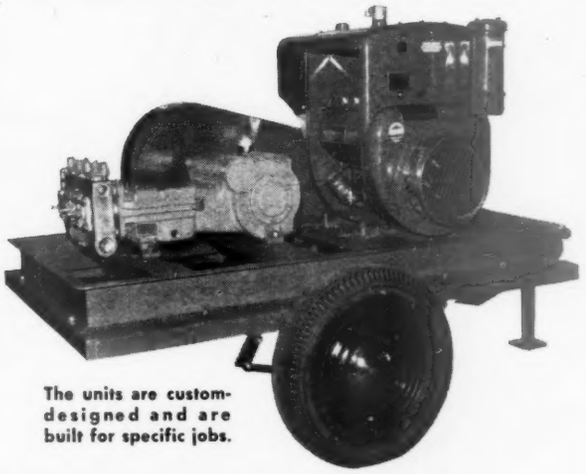
CONCENTRATED EXPERIENCE

over the years has eliminated all weak links on the HARLEY Units powered with

WISCONSIN

Air-Cooled Heavy Duty Engines

Practical HARLEY experience over a long period of time



The units are custom-designed and are built for specific jobs.

THE BEST PUMP, COMPRESSOR, GENERATOR OR ACCESSORY

for the job

For any job in the range 3 to 36 H.P.

These units are sold on a money-back guarantee — The operator must be satisfied.

Built by

The HARLEY Units you need can probably be shipped from stock.

HARLEY SALES CO.

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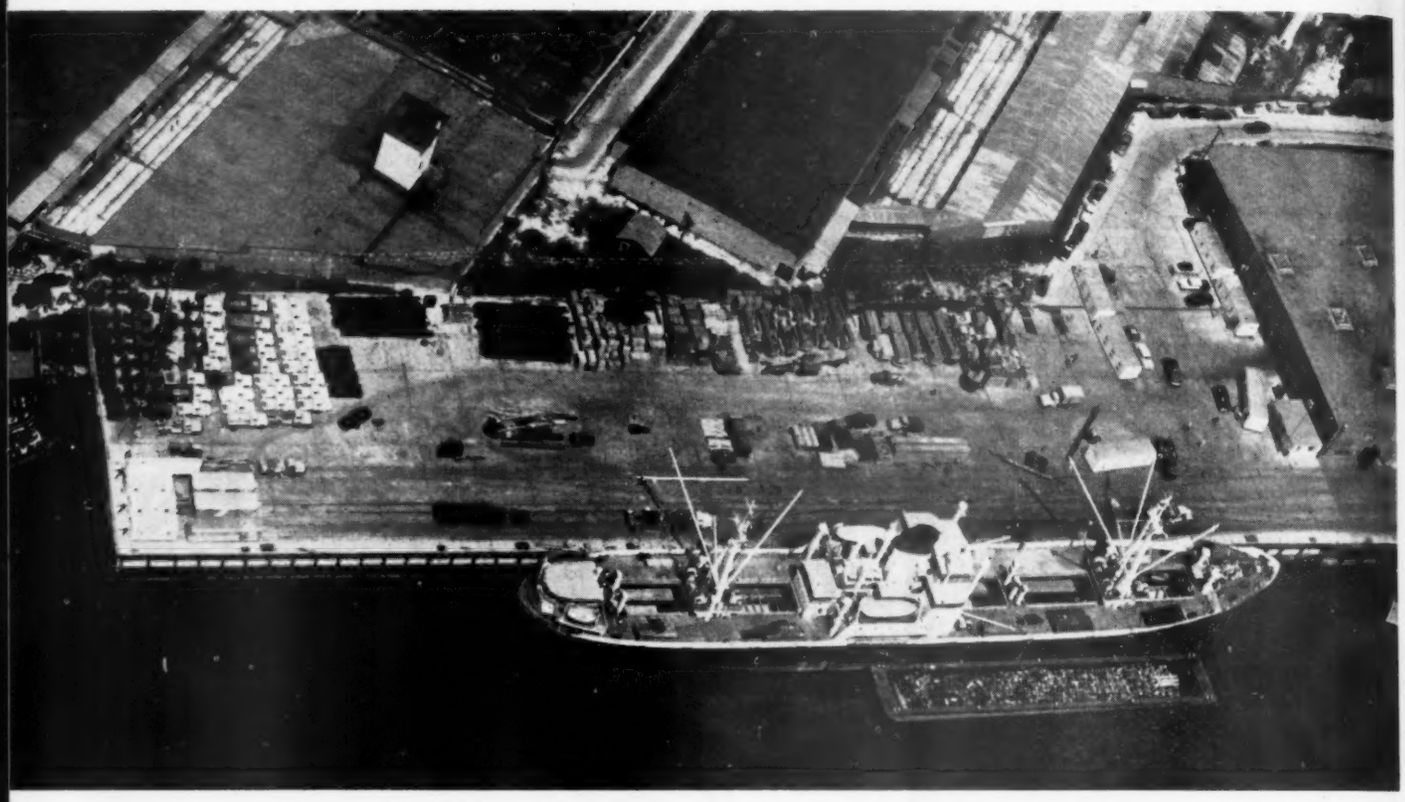
EXCLUSIVE

Pipe Line "Packaged" In Single Ship



Several million pounds of pipe line gear were loaded on the S.S. Belmonte by Lee Construction Corporation for Associated Pipe Line Contractors, Inc., for shipment to Turkey where the Houston pipe line builders will lay 425 miles of 4, 6, and 8-in. products line for the NATO system . . .

Dean Hale
Editor, Oil and Gas Pipelining

IT TAKES A WHALE OF A LOT OF EQUIPment and materials to build 425 miles of 4, 6, and 8-in. products pipe line, especially if it's to be done properly and in a hurry.

It also takes a lot of close figuring to get all this material and equipment on one ship and on its way to Turkey, where Associated Pipe Line Contractors, Inc., Houston, Texas, have a contract for the construction of a 425-mile segment of the NATO pipe line system.

The new line will serve air bases in Turkey. It will extend from Iskenderun, in southern Turkey, northeast to Batman. To cost an estimated $15,000,000, the line will be built for the Republic of Turkey under sponsorship of NATO. Construction is expected to start in mid-September and completion within 14 months.

For this project, Associated turned over the task of packing and shipping the $2,550,000 in equipment and materials to Lee Construction Corporation, old-timers in the business of expert export service.

The task reached a successful culmination in mid-August when the Belmonte cast off its mooring lines in Houston and sailed for Inskenderum, Turkey, well loaded with tractors, trucks, and several million pounds of other pipe line gear.

In addition to performing such functions as obtaining the export license, forwarding, packing, stevedoring, loading, and ship chartering, the Lee firm also built an 11-unit portable campsite for the project.

The complete, compact "little village" that will be used to house the 48 pipeliners who'll build the line was constructed to meet and withstand climate, terrain, and other conditions that will face Associated's personnel. Lee, in order to perform such functions, keeps a continually corrected file on these conditions for just that purpose and provides "made-to-order" housing such as this.

Big Packing Job

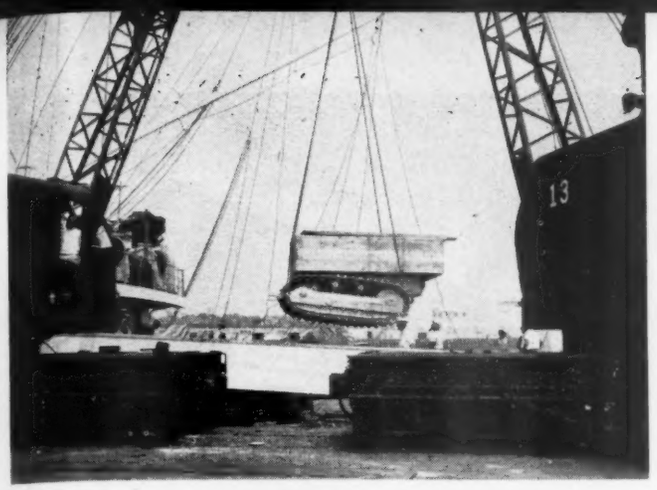
Included in the equipment and materials packed and loaded aboard ship were 65 units of automotive equipment, including pickup trucks, winch trucks, tank trucks, and trailers; six mobile-type house trailers; 21 tractors and their sidebooms, winches, 'dozer blades, etc.; two ditching machines, nine backhoe-crane units, and five air compressors.

Other inventory items included six dope kettles; four skid-mounted tanks; 80,000 lb of welding rod; 4,276,000 lb of bitumastic and pipe line enamel; a new Cessna airplane; 140,000 lb of fibre glass and asbestos pipe wrap; 300,000 lb of pipe and fabricated steel, and 500,000 lb of miscellaneous small pipe line machinery and tools.

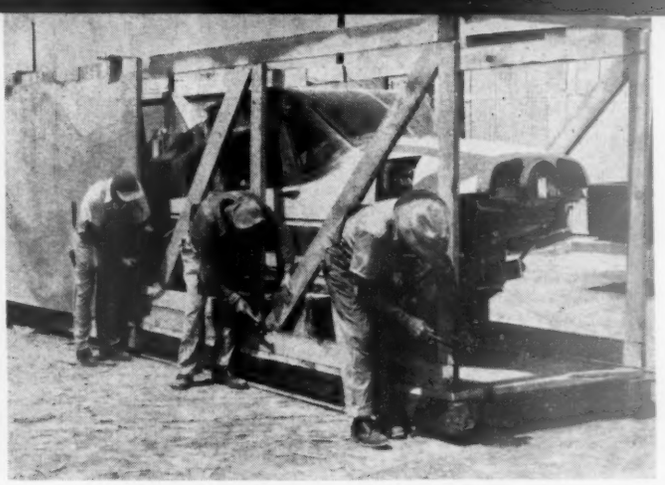
"A Home on Skids". . .

The units that make up the portable campsite have everything, including a "kitchen sink" and other equipment that would make most culinary artists

XUM



... included were 21 crawler tractors, crated like this and stored well below ...



plus a new airplane, to be used to coordinate job activities ...

To build the 425-mile products pipe line ... Associated assembled and Lee packed all of the following materials ... valued at $2,550,000.

65 Units of Automotive Equipment
Pickup trucks
Winch trucks
Tank trucks
Trailers

11 Skid-Mounted Houses, portable, completely furnished, valued at approximately $175,000, with:
Kitchen, Bathroom, Recreation Room, Laundry, Offices, Sleeping Quarters

6 Mobile-Type House Trailers

21 Tractors, with booms, 'dozer blades, winches, etc.

2 Trenching Machines

9 Backhoe-Crane units

5 Air Compressor Units

6 Dope Kettles

4 Skid-Mounted Tanks

1 New Cessna Airplane and ...

180,000 lb of welding rod

4,276,000 lb of primer and enamel

140,000 lb of glass fiber and felt pipe wrap

100,000 lb of pipe and fabricated steel

500,000 lb of miscellaneous pipe line tools and machinery (cradles, line-ups, welders, C&P and C&W machines, etc.)

... and a complete camp of 11 units, including all the modern conveniences of today's homes, as in this sparkling electric kitchen ...

... plus 65 units of automotive equipment of all types ...

... not to mention over 4,000,000 lb of primer and enamel, pipe wrap, welding rod, and pipe ...

XUM

THE NEWEST AND FINEST IN 2-WAY RADIO

. . . with quality and value above all.

The new look—the new sound—now available in the most complete line of precision built, two-way radio models, vibrator or dynamotor powered . . . featuring foolproof 6/12 volt interchangeability, the solution to today's installation problems in mixed fleets of 6 and 12 volt vehicles.

These new Twin-V models give you improved communications range, maximum intelligibility through better receiver sensitivity—better circuitry for control of ignition noise, "hash" and other interference—better audio response for clearer, crisper voice messages that get through even under the worst conditions. The new acoustically matched **Twin-V** radiophone speaker and speaker enclosure assure unexcelled voice reproduction. Instantaneous squelch operation reliably blocks out nuisance noise while maintaining maximum sensitivity to consistently receive the weakest usable signals.

Here is equipment designed to new higher performance standards—built to last . . . built to accommodate changing operating conditions, economically and functionally . . . built to more readily accommodate conversion to split-channel conditions. All Motorola units are fully field tested, proved in use, proved for sustained peak performance, proved for minimum maintenance.

with MANY NEW, EXCLUSIVE FEATURES

There is a model designed for each and every application in the 24-54 mc., 144-174 mc., and 450-470 mc. frequency ranges, with a wide selection of transmitter power output ratings to serve your varied communications requirements. Take your choice of compact, economical, vibrator powered models or rugged, long life, dynamotor powered units to serve your specific operational needs.

Get the complete details. Write, phone or wire:

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MOTOROLA COMMUNICATIONS & ELECTRONICS, INC.
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ROGERS MAJESTIC ELECTRONICS LTD. TORONTO, CANADA

Motorola consistently supplies more mobile and portable radio than all others combined.
Proof of acceptance, experience and quality.
The only COMPLETE radio communications service—specialized engineering . . . product . . . customer service . . . parts . . . installation . . . maintenance . . . finance . . . lease.
"The best costs you less—specify Motorola."

envious.

All 11 of the buildings have 8-ft ceilings. All are 10 ft wide, except the kitchen, which is 19 ft wide. All are mounted on welded steel skids and are double floored with heavy plywood, interleaved with rock wool insulation. Reflective vapor-seal insulation is also used in the walls, with interior facing of natural-finished knotty pine. Roofing is well-sealed sheet aluminmum.

Paint, wiring, and window and door units are designed for long, hard use.

The six bunk houses, each containing four rooms for two men each, are 34 ft long. Each room is furnished with a double-deck bunk, rubber foam mattresses, rubber foam pillows, box springs, desks, chairs, reading lamps, and other fixtures for the comfort and morale of the men.

The air-conditioned recreation house is 40 ft long, with comfortable chairs, tables for games, and a host of other facilities designed to help the men while away their hours of relaxation. Kerosine heaters are used throughout the camp.

The 40-ft dining house is also air-conditioned. Tables and chairs are all of the folding type.

Just Like Home

The dining room unit is designed so that it can be attached both to the recreation house and the kitchen unit, another 40-ft building. The kitchen is fitted with a host of electric appliances, including two 15-cu ft upright freezer units, a 40-cu ft reach-in refrigerator, a 200-lb-per-day cube-ice making machine, a 40-gal table top water heater, a 20-qt food mixer-meat grinder combination and two electric ranges.

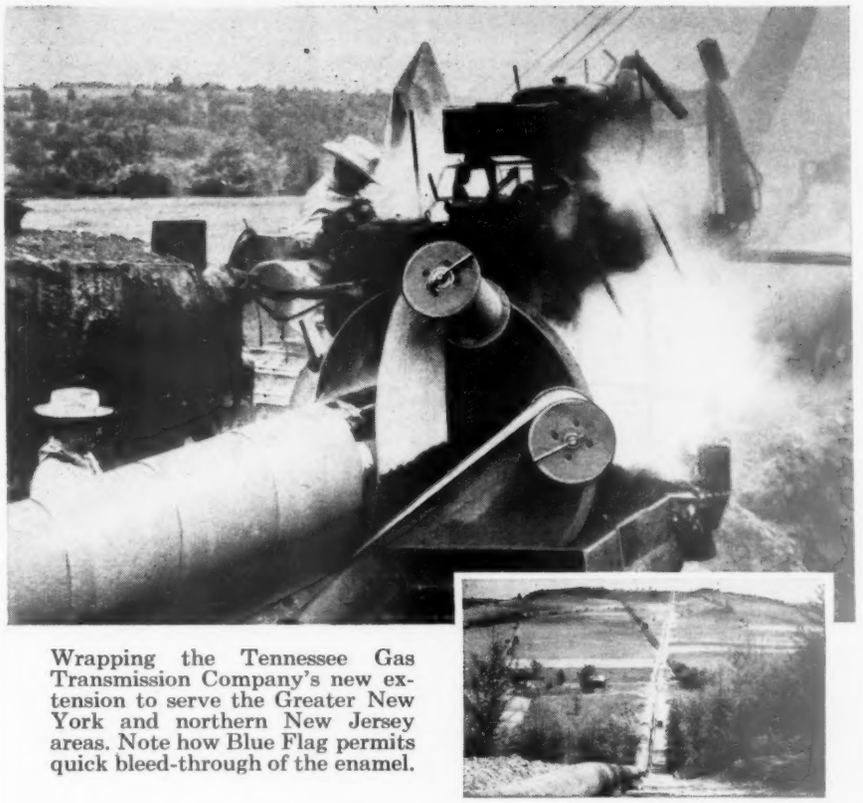
Thirty feet of the remaining residence building are devoted to the bath and sanitary facilities, which include four lavatories, four commodes, two wall-type urinals, and four showers, besides dressing benches and lockers.

An 82-gal water heater serves both the bath compartment and the 10-ft laundry room, which is fitted with two automatic washing machines and two automatic driers, plus steam irons, dry irons, and ironing boards.

The office building is divided into three offices, two of which are 10 ft long, with the other one 20 ft long. Each of the offices is equipped with a half-ton air conditioner and a 35,000 Btu kerosine heater.

Two diesel-driven electrical plants, each rated at 28-kw, will supply the 110-v and 220-v current used in the camp.

Portable wiring will be used to connect each of the buildings with the power source. Plumbing will be run between the floor layers and then between the skids to protect it. * * *



Wrapping the Tennessee Gas Transmission Company's new extension to serve the Greater New York and northern New Jersey areas. Note how Blue Flag permits quick bleed-through of the enamel.

"Holidays" averaged fewer than 3 per day with Blue Flag Pipe Wrap

Blue Flag almost eliminated "holidays" on Tennessee Gas Transmission Company's new 250-mile, 24-inch line, over rough ground in eastern Pennsylvania.

The dope gang reported an average of fewer than 3 "holidays" per day—unusually low for such difficult terrain.

The fine glass fibers in Blue Flag Pipe Wrap are made of highly inert glass. They are formed into a strong, uniformly porous mat which permits quick bleed-through of hot enamel and holds "holidays" to a minimum.

Pipeline companies find that Blue Flag increases the strength of the enamel coating, gives it exceptional resistance to cracking, and helps protect the line against corrosion.

Like Tennessee Gas, you can add years to the service life of your pipeline with Blue Flag Pipe Wrap, safeguard your large original investment for a small fraction of the entire cost. It's available from strategically located warehouses of Blue Flag distributors.

SEND FOR FREE FOLDER on L·O·F Glass Fibers' complete line of pipe wraps engineered for effective corrosion control. Write: L·O·F Glass Fibers Company, Dept. 72-10-, 1810 Madison Avenue, Toledo 1, Ohio.

L·O·F GLASS FIBERS

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Makers of glass fibers by the exclusive "Electronic-Extrusion" process

BLUE FLAG

A COMPLETE LINE FOR PIPELINE PROTECTION

BLUE FLAG Reinforcing Pipe Wrap, **DURAMAT** Protective Outer Wrap, **DURAMESH** Pipeline Fabric, **DURATAPE** Pipe and Joint Wrap

CP "Power Vane" Rotary Compressors are available with

Hercules gasoline engines in capacities of 125 and 2

Here's a pipeline rig that's go

XUM

125 and 210 cfm; and General Motors diesel engines in capacities of 210, 365, 600 and 900 cfm.

...it's going places

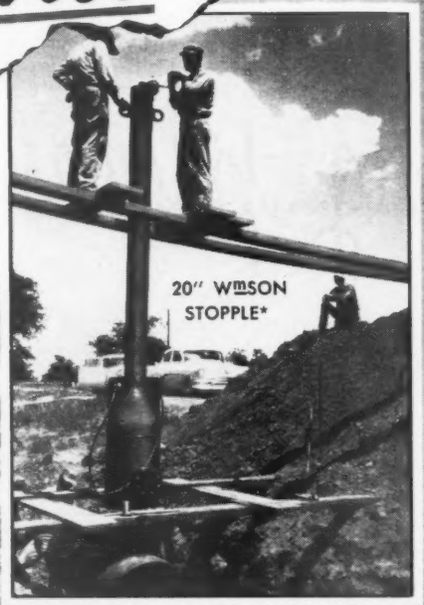
Now you can have a completely mobile ditching rig in one self-contained unit! It's a dependable CP "Power Vane" Rotary Compressor and GTD-300 Trenchdril combined with your own side boom tractor. The complete portability and rugged design features of the CP Rotary plus the powerful feed and strong rotation of the Trenchdril make a powerful drilling combination when the going gets tough. For details write, *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.*

Here's the complete unit in operation!
The CP Rotary Compressor operates at peak efficiency even during off-level operation.

Chicago Pneumatic

PNEUMATIC TOOLS • AIR COMPRESSORS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS • AVIATION ACCESSORIES

16" and 20" High-Pressure Gas Lines Modified *in service*



COLORADO INTERSTATE GAS CO.
USES WmSON STOPPLE* TO FACILITATE INSTALLATION OF BLOCK VALVE ON THEIR 20" GAS TRANSMISSION LINE *WITHOUT INTERRUPTION OF GAS SERVICE TO THE CITY OF DENVER*

OPERATORS TURNING CRANK TO LOWER THE STOPPLE* SEALING ELEMENT INTO PIPELINE

MANUFACTURERS LIGHT & HEAT CO.
OF PITTSBURGH, *CONTINUED GAS SERVICE* TO SEVERAL THOUSAND CUSTOMERS IN THE VICINITY OF WHEELING, WEST VA. WHILE INSTALLING A NEW PRESSURE REDUCING STATION ON THEIR 16" GAS TRANSMISSION LINE

WRITE FOR *RENTAL-PURCHASE* INFORMATION AND LITERATURE ON WmSON STOPPLES AND WmSON-HILLCO TAPPING MACHINES

*Patent Pending

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REPRESENTATIVES: Houston • Pittsburgh • Amarillo • Casper • Provo, Utah • Joliet, Illinois • Los Angeles • San Francisco
Bartlesville, Okla. • Edmonton • London, Ontario • Calgary • Buenos Aires • Durban, Natal, South Africa

Boom! Trench is blasted in rocky country between Cahone and Dove Creek, Colorado, on first section of new Pacific Northwest line.

P 624.

Pacific Northwest Pipe Line Construction in First Phase

Nearly 80 per cent of new gas system to Northwestern states now being built

WORK ON 1211 MILES OF THE PACIFIC Northwest Pipe Line Corporation's new natural gas system from the San Juan Basin to Washington and Oregon is underway with eight contractors engaged in laying 14 sections of the new pipe line.

Contracts for the initial phase of construction were awarded in May and June, and most of the contractors have kicked off on their respective sections. Balance of the uncontracted portions of the system are in Washington and Oregon. Completion of work underway is expected in the summer of 1956 and gas deliveries are expected to be underway later in 1956. Cost of the new system is estimated at $165,000,000.

Highlights of the Pacific Northwest Pipe Line include:

. . . some two billion cu ft of gas will be required to initially fill the line upon completion, at a pressure of 750 psi.

. . . the main line and branches will require some 317,000 tons of steel.

. . . 92,400-hp will be installed in 16 compressor stations on the line, with fuel requirements for these stations estimated at 18,000,000 cu ft per day, to pump gas at a rate of approximately 15 miles per day.

. . . a private microwave communications system, 1200 miles in length, will be built at a cost of over $1,100,000.

. . . more than 75 major and minor streams will be crossed by the main line, including the Colorado and Columbia Rivers.

. . . reserves for the line have been estimated as being sufficient for 25 years operation, assuming no new discoveries.

. . . protection against corrosion will be insured by both coating and wrapping of the line and cathodic protection throughout.

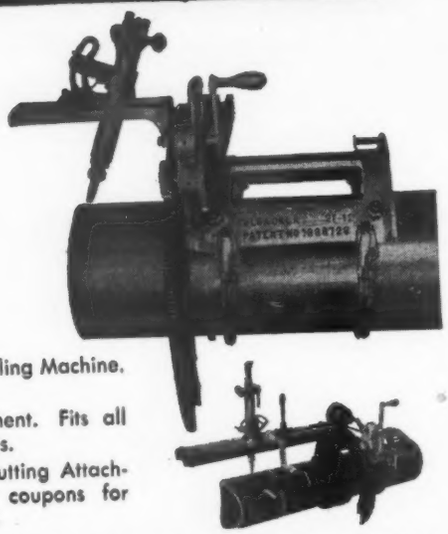
Contractors for the first phase include:

River Construction Corporation, Fort Worth, Texas. Two sections of 26-in. totaling 150 miles between Ignacio and Moab, Utah.

R. H. Fulton and Company, Lubbock, Texas. Two sections of 26-in.

*Mathey PIPE CUTTING AND BEVELING MACHINES

- **QUICKEST IN OPERATION**
  - Just slips over pipe
  - No hinges or latches to open or close
- **LIGHTEST WEIGHT**
- **FIVE MODELS** (for pipe from 4" to 36 inches)
- **ECONOMICAL**
- **FOR RENTAL OR PURCHASE**



Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

Phone 3-3623 and 54-5141

C. A. MATHEY MACHINE WORKS, INC.
212 SOUTH FRANKFORT ● TULSA, OKLAHOMA

PROTECT OIL AND GAS PIPELINES *with* NICOLET ASBESTOS PIPELINE FELT

FIGHT PIPELINE CORROSION WITH ANY OF THESE NICOLET FELTS

★ Nicolet 15 lb. *Asbestos* Felt, Tar or Asphalt Saturated
★ Nicolet 15 lb. *Asbestos* Felt, parallel glass yarn reinforced, Tar or Asphalt Saturated
★ Nicolet 15 lb. *Asbestos* Felt, Perforated on Uniform Centers, Tar or Asphalt Saturated
★ Nicolet "Tufbestos" 8 lb. *Asbestos* Felt, reinforced with parallel glass yarns, Tar or Asphalt Saturated
★ Nicolet "Reflecto" 8 lb. or 10 lb. White Neoprene Treated *Asbestos* Felt, glass yarn reinforced

Asbestos is *inorganic*. We believe this *inorganic* material, which comprises the major contents of the base felt, provides a longer-lasting shield protection for all pipeline enamel coatings.

Write for your copy of the new Nicolet Catalog
ALL INQUIRIES WELCOME

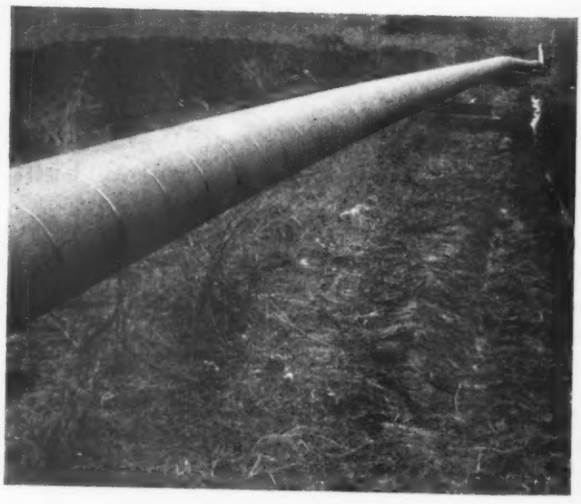
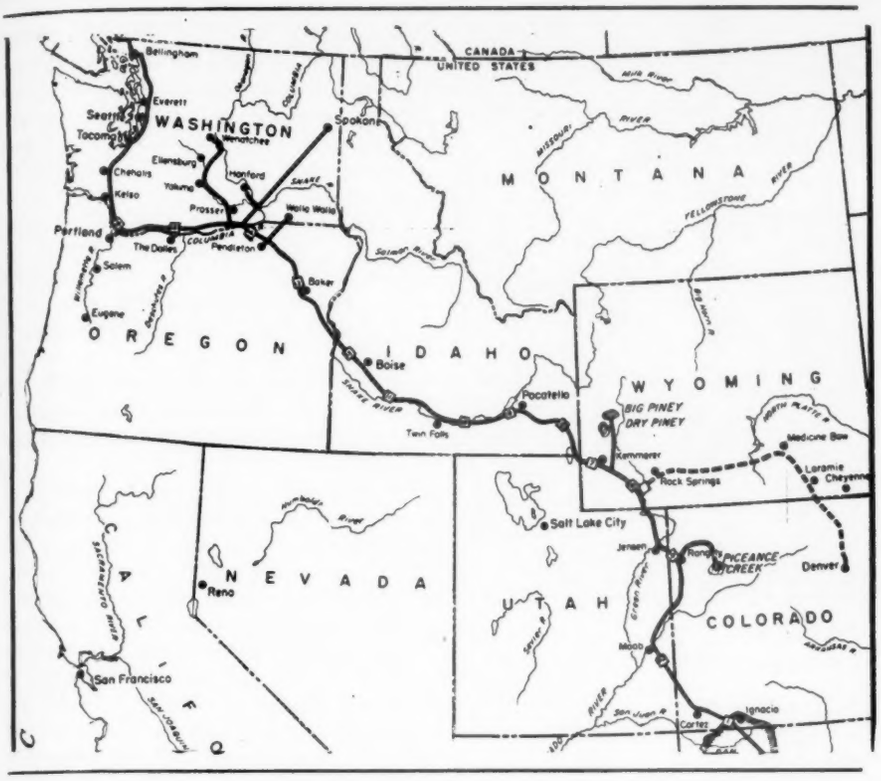


Photo showing Nicolet Felt Protecting Pipeline

The Felt With a Future

MANUFACTURED BY:
NICOLET INDUSTRIES, INC.
70 PINE STREET
NEW YORK 5, N. Y.



Map shows route of new 1500-mile system. Dotted line indicates connecting line of Colorado Interstate Gas Company.

totaling 160 miles between Moab and Jensen, Utah.

Associated Pipe Line Contractors, Inc., Houston, Texas. One section of 26-in., 77.6 miles, between Jensen and Green River, Wyoming.

A. J. Curtis Construction Company, Casper, Wyoming. One section of 22-in., 82.8 miles, from Green River to Sage, Wyoming.

B. & M. Construction Corporation, Oklahoma City, Oklahoma. One section of 22-in., 90 miles, between Sage and Lava Hot Springs, Idaho.

Midwestern Constructors, Inc., Tulsa, Oklahoma. One section of 22-in., 95 miles, between Lava Hot Springs and Burley, Idaho.

H. B. Zachry Company, San Antonio, Texas. Two sections of 22-in., 214 miles, between Burley and Payette, Idaho, at the Oregon-Idaho border.

Fulghum Contracting Corporation, Harrisburg, Pennsylvania. Two sections of 22-inch., 198 miles between Payette and the Oregon-Washington border.

A. J. Curtis Construction Company, Casper, Wyoming, 54 miles of 16-in. lateral and 31 miles of 2 to 18-in. gathering system from Kemmerer, Wyoming to the Big Piney field.

R. H. Fulton and Company, Lubbock, Texas, 43 miles of 10-in. lateral line and 16 miles of 3 to 10-in. gathering system from Rangely, Colorado to the Piceance Creek field. * * *

For Pipeline Construction ANYWHERE

Sheehan has the equipment — the men — the experience of many jobs successfully completed. For your pipeline construction, call Sheehan.

SHEEHAN

PIPELINE CONSTRUCTION CO.
TULSA, OKLAHOMA

National Bank of Tulsa Building

Ditching machines prepare the "bed" for Texas Eastern's new 377-mile, 30-in. line between Beaumont and Kosciusko.

Texas Eastern, Subsidiary Companies Have $94,000,000 Program Underway

Nearly 500 miles of new line, 127,420 compressor horsepower, and conversion of "Little Big Inch" included in the various expansion programs

Crossing the Atchafalaya River with concrete-coated 30-in. pipe. Dual lines are being laid on all major stream crossings.

CONSTRUCTION OF A NEW 377-MILE, 30-in. gas pipe line between Beaumont, Texas, and Kosciusko, Mississippi, by Texas Eastern Transmission Corporation is well underway with six pipe line spreads and five river crossing jobs in progress.

The new line is a part of facilities being constructed by the company as certificated by the Federal Power Commission to maintain the firm's natural gas delivery capacity after reconversion of the major portion of the Little Big Inch pipe line, between Beaumont and Moundsville, West Virginia, from natural gas to petroleum products service.

Overall cost of the new facilities is estimated at $70,883,000. They include eight new compressor stations, additions to certain existing stations, the new Beaumont-Kosciusko line and 100 miles of additional lateral and connecting smaller diameter lines. The new facilities will increase the capacity of Texas Eastern's 30-in. line by an amount equal to that now being carried by the Little Big Inch, approximately 200,000,000 cu ft daily.

The new 30-in. line extends from near Beaumont through southern Louisiana, southern and central Mississippi, and connects with an existing 30-in. line at Kosciusko. It crosses four major rivers and one bayou — the Neches, Sabine, Atchafalaya, and Mississippi rivers and Bayou Courtableau. In each case, these crossings will have two lines for added protection.

Contractors for the line construction include: *Houston Contracting Company,* 59 miles, Beaumont to near DeQuincy, Louisiana; *Tulsa Williams Company,* 118 miles, (two sections) from near DeQuincy to the Mississippi River near New Roads, Louisiana; *H. C. Price Company,* 134 miles (two sections), east bank of the Mississippi to near Clinton, Mississippi, and *H. B. Zachry Company,* 64 miles, from Clinton to Kosciusko, Mississippi.

Pentzien, Inc., will construct the Neches, and Atchafalaya River crossings; *Missouri Valley Dredging* will install the Sabine and Bayou Courtableau crossings, and the Mississippi crossing will be made by *J. Ray McDermott Company.*

Brown & Root, Inc., is furnishing field supervision for the pipe line work and will construct with its own crews the compressor stations.

New Compressor Horsepower

A total of 127,420 horsepower will be added by Texas Eastern, 91,400-hp in the new compressor stations and 36,020 in existing stations. Two new reciprocating stations will be installed in Texas, at Booth and Vidor. Booth station will have two 1100-hp recipro-

Map shows location of Texas Eastern Transmission and subsidiary company systems, route of new 30-in. line, proposed conversion of "Little Big Inch" system for 1168 miles between Beaumont and Moundsville, West Virginia.

cating engines, Vidor will have five 1000-hp reciprocating units. An 8800-hp station will be built near Holbrook, Pennsylvania. Three new electric motor driven centrifugal stations, each with one 15,000-hp unit, will be constructed at Egypt, Mississippi; Mt. Pleasant, Tennessee, and Tompkinsville, Kentucky. Two gas turbine centrifugal stations, each with a 7600-hp unit, will be built at Athens, Ohio and Owingsville, Kentucky.

Additions to existing stations include 5000-hp in reciprocating units at Kosciusko, Mississippi; 3520-hp in reciprocating units at Danville, Kentucky; 7500-hp in electric motor driven centrifugal units each at three stations — Barton, Alabama, Gladeville, Tennessee, and Wheelersburg, Ohio, and 5000-hp in electric motor driven centrifugal units at Berne, Ohio.

Reconversion

Following completion of the new facilities, Texas Eastern plans to reconvert the 1168-mile Little Big Inch line to products transportation. Cost of the project is estimated at $14,800,000.

Operation of the line as a common carrier of refined oil products including LPG, from the Texas Gulf Coast area to a terminal on the Ohio River at Moundsville is anticipated on or before the fall of 1956.

Penn-Jersey Adding Facilities

Greater flexibility for Texas Eastern's operations in the Philadelphia-New Jersey delivery area will be provided as a result of FPC authorization on a joint application of Texas Eastern and Texas Eastern Penn-Jersey to shift 10,000-hp installed or authorized on the Texas Eastern system to the Penn-Jersey system.

The shift will allow construction of two new 5000-hp stations on the Penn-Jersey line at Perulack and Grantville, Pennsylvania. Both will be gas turbine centrifugal installations. Other facilities authorized include an additional 3300-hp in reciprocating units at Texas Eastern's Linden, New Jersey station and construction of 11 miles of loops in the Philadelphia area. Cost of the new facilities is estimated at $2,597,400 for Texas Eastern and $836,000 for Penn-Jersey.

New Wilcox Trend Facilities

Wilcox Trend Gathering System, Inc., a Texas Eastern subsidiary, will increase its daily capacity to 200,000,000 cu ft with the addition to its system of facilities given FPC authorization.

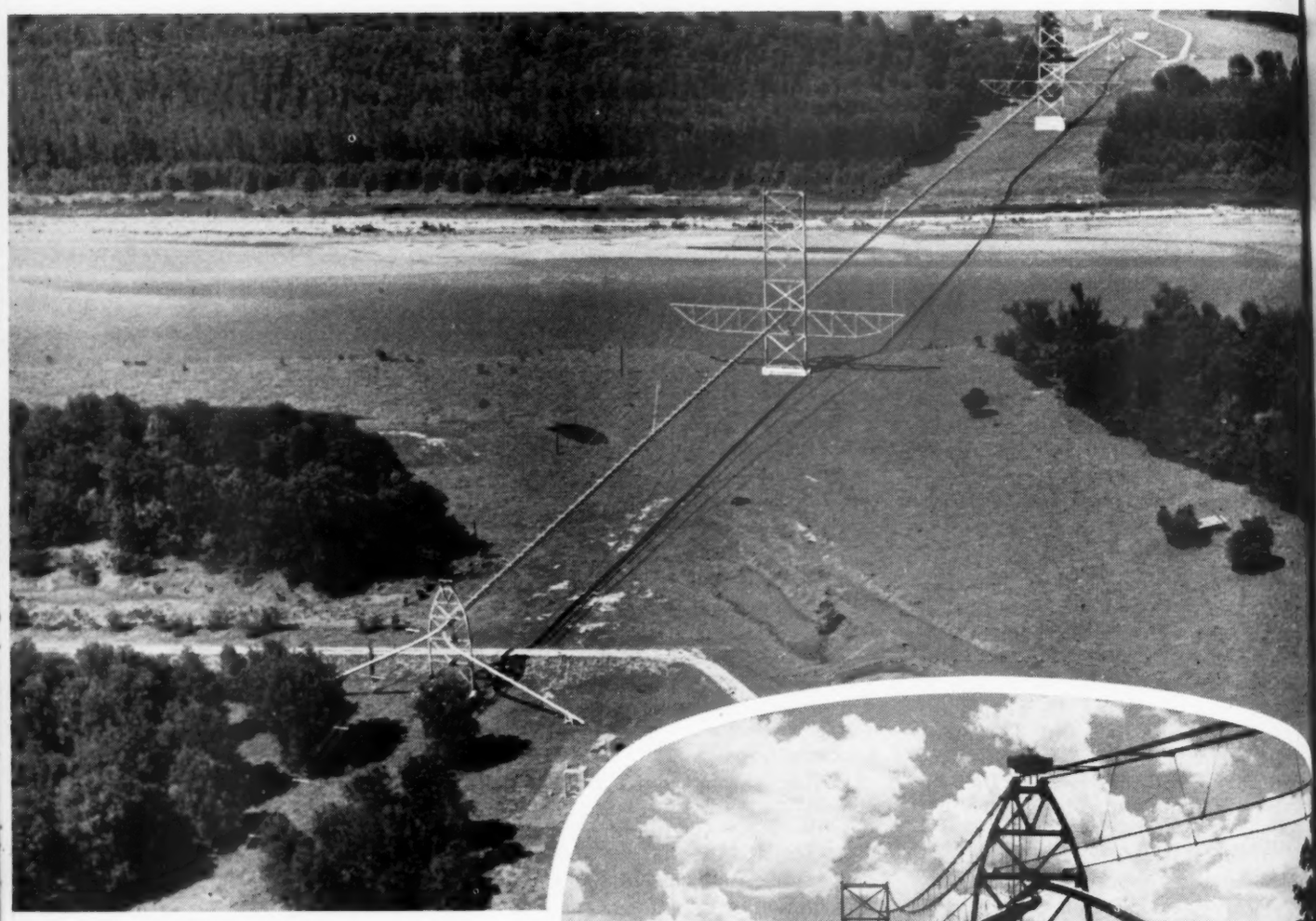
These include a new 2000-hp compressor station near Charco, Texas; addition of 2200-hp to an existing station at Thomaston, Texas; 16 miles of 16-in. loop line near Provident City, Texas; some additional smaller lines and a 75-hp field compressor station. Cost of these new facilities is estimated at $2,900,000. * * *

Backhoe gouges a bridge between ditch sections in Louisiana.

Pipe gang at work in Mississippi on the new 30-in. line.

PITTSBURGH • DES MOINES

OVER A QUARTER OF A CENTURY'S EXPERIENCE AND CRAFTSMANSHIP in PIPELINE SUSPENSION BRIDGE CONSTRUCTI



Designed by Matthews and Kenan, Consulting Engineers, San Antonio, Texas

"A LOT OF WATER UNDER THE BRIDGE"

Typical of the service rendered by Pittsburgh-Des Moines Pipeline Bridges is this Red River suspension bridge crossing in Louisiana. Built in 1945, the 3200 ft structure originally carried one 24" natural gas pipeline. In 1953, a second line of equal capacity was added. • Over the years, a lot of water under the bridge—a lot of gas transported dependably over the stream! • For your pipeline crossing needs, call upon the special experience and ability of Pittsburgh-Des Moines. Your inquiries are welcome.

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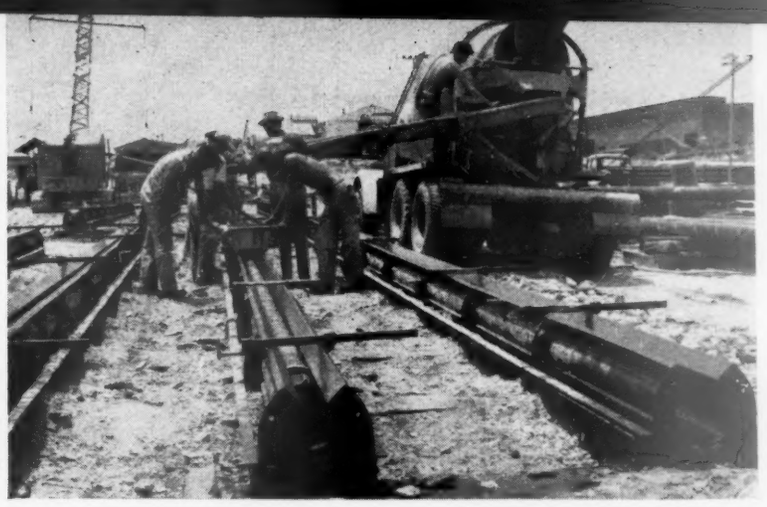
◆ Mechanical agitator rotates pipe constantly while concrete is poured into form.



◆ Pipe is placed in joint-length, hinged forms that form a receiving trough. Concrete mix is poured into a hopper that is movable along full length of the joint.

P 623.

Texas Gas Corporation Line Crosses Galveston East Bay

16,800 ft of concrete coated pipe used in crossing; new process used in coating

A 16,800-FT UNDERWATER CROSSING of Galveston East Bay highlights the construction of a 13-mile, 6-in. gas pipe line laid this summer by Texas Gas Corporation to connect the firm's Jackson Pasture line in Chambers County, Texas, to the Caplen Field on Bolivar Peninsula.

An interesting feature of the Bay crossing project was the use of a new process called "Roto-Cote" for coating the 6⅝-in. OD pipe. A special concrete formula was used that not only weights the pipe but protects it from marine life and corrosion attacks, and the coating was applied in a unique fashion.

Pipe is first given a conventional coating and wrapping, followed by manually spiralling of 1-in., 18 gage wire mesh around the pipe, which is then locked upon the pipe.

The pipe is then placed in a specially constructed joint-length steel form, hinged for easy locking or release, forming a trough to receive the pipe. Concrete mix is then poured into a movable hopper along the full length of the joint-trough. While the concrete is being poured, mechanical rotating equipment turns the pipe, insuring a uniform thickness over the entire length. Coating on the 6⅝-in. pipe is approximately 1⅛-in. thick. The wire mesh remains in the approximate center of the coating. After setting for a short time, the pipe is smoothed and the hinged forms released.

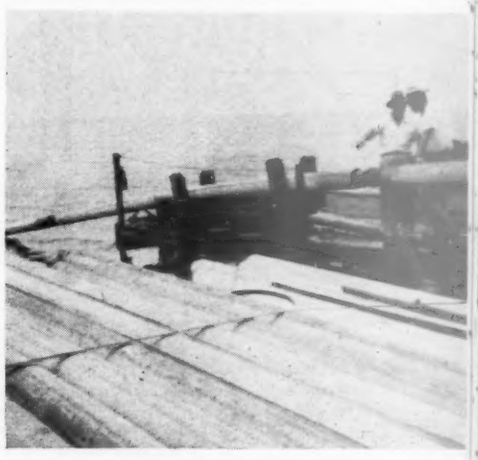
In addition to the 16,800 ft laid in the Bay crossing, pipe coated in this manner was also used for various canal crossings.

Construction of the Bay crossing was by the ramp-barge method, the pipe laid to a depth of 9-ft below mean low tide. After installation, it was hydrostatically tested to 1200 psi. Brown and Root, Inc., was prime contractor on the project. The Anchor-Wate Company, Houston, Texas, was contractor for concrete coating the pipe. * * *

◆ Pipe is spirally wrapped by hand with 1-in., 18-gage wire mesh.

◆ Pipe after coating is smooth, stacks and handles easily.

◆ Entire 16,800-ft crossing with coated 6⅝-in. pipe was by ramp barge.



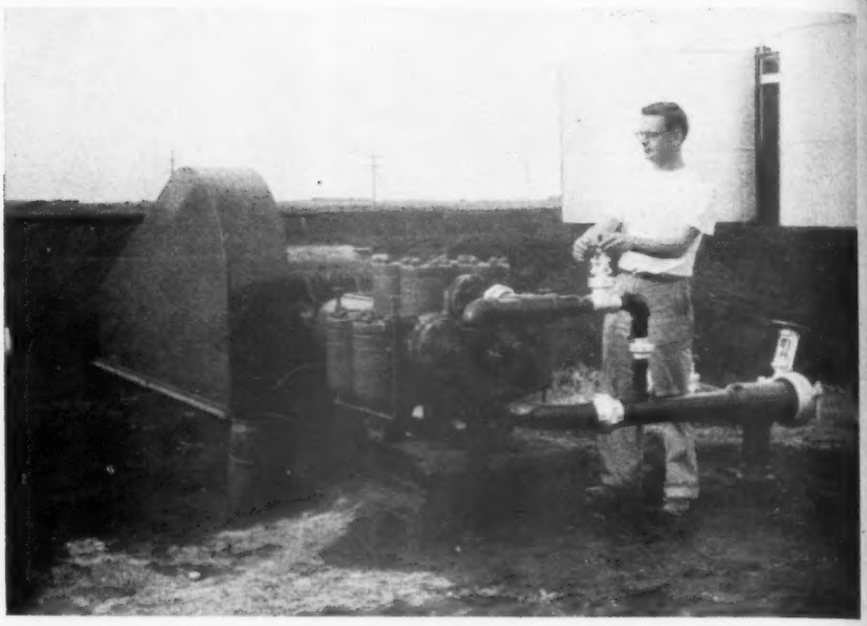
Combination Units Provide

Gathering System Economy

L. O. Rowland

TO handle both low and high pressures in a single gathering system, serving three principal oil fields in southwestern Manitoba, Trans-Prairie Pipelines, Ltd., has put into operation a unique combination pumping system. Under the direction of general manager Dick Fisher, who has been with the company since its inception a little more than a year ago, the Trans-Prairie system has grown from initial throughput of some 6000 bbl a day to a current flow rate that in recent months has exceeded 16,000 bbl a day for short terms of operation.

The two types of pumps used in the combined operation are said to provide the most economical operation from a cost standpoint. At the same time they provide safety from over-pressure by means of reliable control instruments.



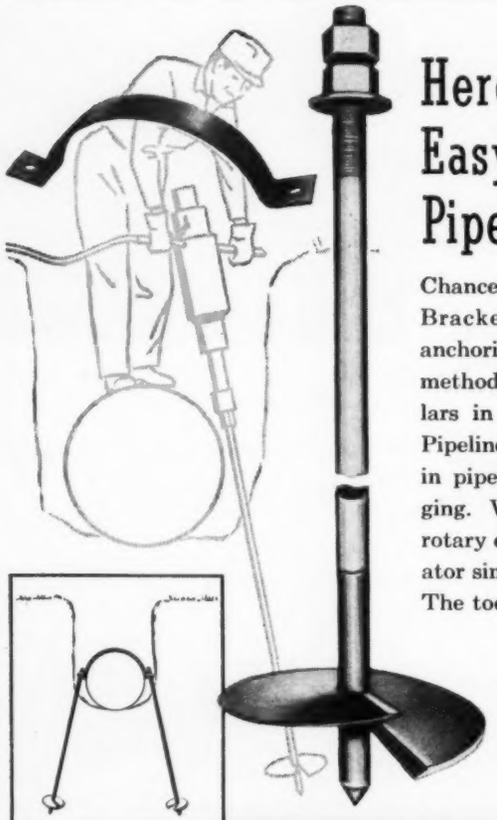
Duplex piston pump, electrically-driven, provides high discharge pressures for the line. Pump takes suction from large tanks in field batteries and from discharge side of a number of smaller centrifugal pump units that take suction from smaller tanks.

The Trans-Prairie system consists of about 40 miles of pipe line, picking up crude from the Daly, Virden-Roselea, and North Virden oil fields and delivering it to transfer tanks, from which it is pumped in 5000-bbl slugs into the Interprovincial Pipe Line Company's main line at its Cromer pumping station, three miles south of the southwest end of the Daly field.

The line from Daly to the Cromer station is 6 in., as is the one that links the Virden-Roselea field with the Daly field. Laterals are 3 and 4 in., as are the spur lines that extend to the North Virden field and the eastern sector of the Virden-Roselea field.

The system has been under considerable expansion this year, as development drilling in the Virden area has added several new tank batteries, especially in the northern part of the North Virden field, and it appears likely that several more miles of gathering lines will be required before next winter to pick up all the current production.

Forecast producibility of the region tributary to the Trans-Prairie pipe line is about 20,000 bbl a day, but this estimate is subject to upward revision due to completion of two new discovery

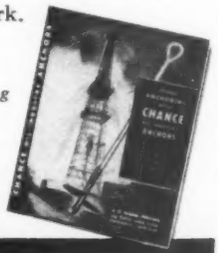


Here's the Fast Easy Way to Anchor Pipelines

Chance Pipeline Screw Anchors and Brackets greatly simplify pipeline anchoring in comparison with other methods and they save hundreds of dollars in pipeline construction. Chance Pipeline Screw Anchors can be installed in pipeline ditches without extra digging. With a pneumatic or electric rotary drill or impact wrench, the operator simply guides the anchor in place. The tool does the work.

Can be installed in ditch without extra digging.

Write for a catalog of Chance Earth Anchors for the Oil Industry.



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315 MILES OF 36-INCH - - FOR LOOPS IN 1955

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A Transco innovation is the installation near Houston of a centrifugal compressor driven by a four-cycle gas engine.

To meet the expanding need for natural gas in the New York-New Jersey-Philadelphia Metropolitan Areas and in the Southern Piedmont, Transco is increasing allocations to 48 public utility, industrial and municipal customers.

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

Engaged in making a Market for Texas and Lousiana Natural Gas

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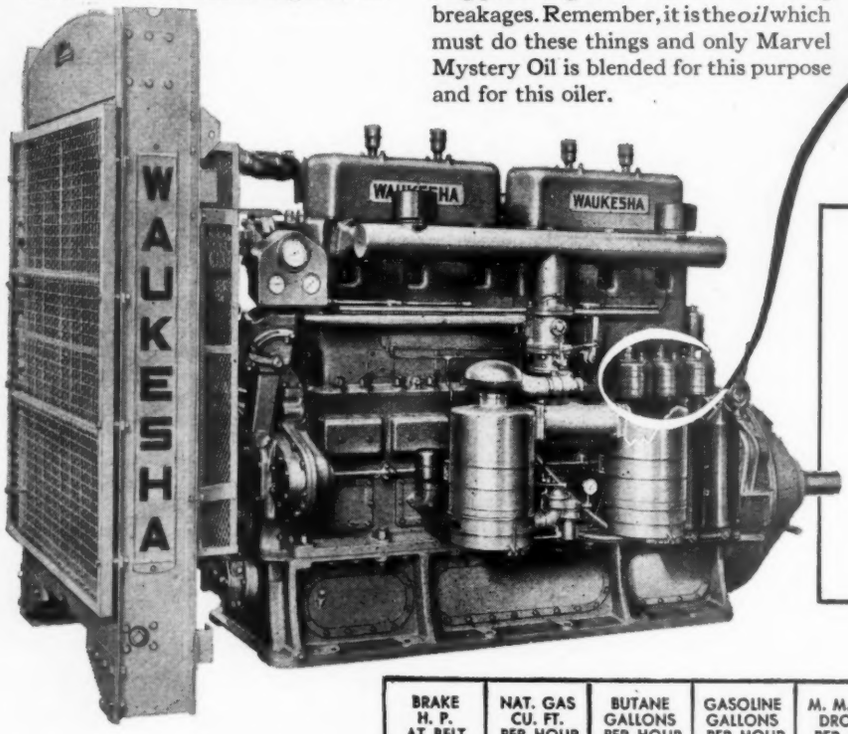
MARVEL INVERSE OILER-
Vital Part of World's Finest Engines

Engine manufacturers think so highly of the Marvel Inverse Oiler they have incorporated it as a vital unit in their engines' lubrication systems.

They have found that engines, equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down-time" low by extending periods between overhauls.

The famous Waukesha Engines, one of which is pictured below, is an example. A truly fine performer, it is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant of all.

The Marvel Inverse Oiler feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. Keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages. Remember, it is the *oil* which must do these things and only Marvel Mystery Oil is blended for this purpose and for this oiler.



The Marvel Inverse Oiler

is an integral part of the Waukesha 550 H.P., 1200 RPM gas fuel engine. Operating off the intake manifold, these three completely automatic Oilers feed Marvel Mystery Oil exactly in proportion to engine loads . . . give direct protection to the all-important upper cylinder areas.

This Chart shows the proper setting for constant load engines

BRAKE H. P. AT BELT	NAT. GAS CU. FT. PER HOUR	BUTANE GALLONS PER HOUR	GASOLINE GALLONS PER HOUR	M. M. OIL DROPS PER MIN.	M. M. OIL HOURS PER QUART
10	115.	1.07	1.12	4	228
15	172.5	1.60	1.68	6	152
20	230.	2.14	2.24	8	114
25	287.5	2.67	2.80	10	91
30	345.	3.21	3.36	12	76
35	402.5	3.74	3.92	14	65
40	460.	4.28	4.48	16	57
45	517.5	4.81	5.04	18	50
50	575.	5.35	5.60	20	45
60	690.	6.42	6.72	24	38
70	805.	7.49	7.84	28	32
80	920.	8.56	8.96	32	28
90	1035.	9.63	10.08	36	25
100	1150.	10.70	11.20	40	22
120	1380.	12.84	13.44	48	19
140	1610.	14.98	15.68	56	17
160	1840.	17.12	17.92	64	14
180	2070.	19.26	20.16	72	12
200	2300.	21.40	22.40	80	11
225	2587.5	24.00	25.20	90	10
250	2875.	26.75	28.00	100	9
275	3162.5	29.42	31.10	110	8
300	3450.	32.10	33.60	120	7

Chart shows total oil consumption

EXAMPLE:—If you use 805 cu. ft. of dry gas, 7.49 gallons of butane or 7.84 gallons of gasoline, your H.P. is about 70, so adjust oiler to feed 28 drops per minute. You will then receive about 32 hours per quart of MARVEL MYSTERY OIL.

If engine load increases after setting for normal load, oiler will automatically increase its feed, decreasing when load is lessened.

To determine drop count per oiler when more than one is used on an engine—divide recommended drop count by number of oilers.

NOTE: Guarantee on oiler is void if any other oil than MARVEL MYSTERY OIL is used. Some *engines* also carry this guarantee policy.

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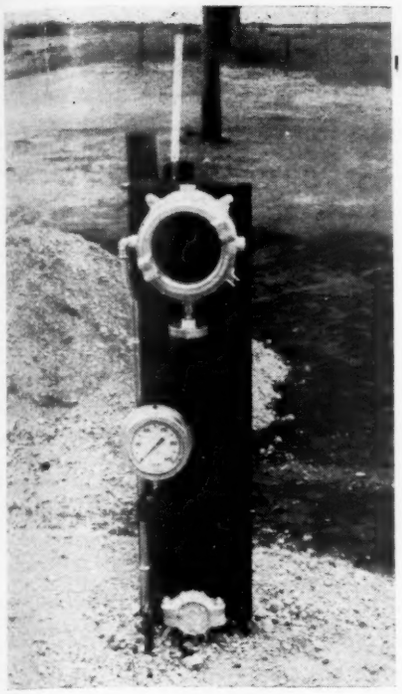


Pressure control for the duplex pumps is provided by this unit. The two-stage pressure switch stops pump on either low suction pressure or high discharge pressure.

wells since the forecast was made. The pumping system design thus will be of particular value and significance in the high pressure area where this rapid development is taking place.

The high pressures are handled by electrically driven duplex piston pumps, each centrally placed in the middle of a group of batteries. In general, an attempt has been made to place the duplex pumps adjacent to the batteries with the largest production intake. Grouped in a more or less circular pattern around the duplex pump, in each area, are several pumps of centrifugal type, each of which serves a battery with a normally smaller intake and which pumps into the suction side of the adjacent piston pump.

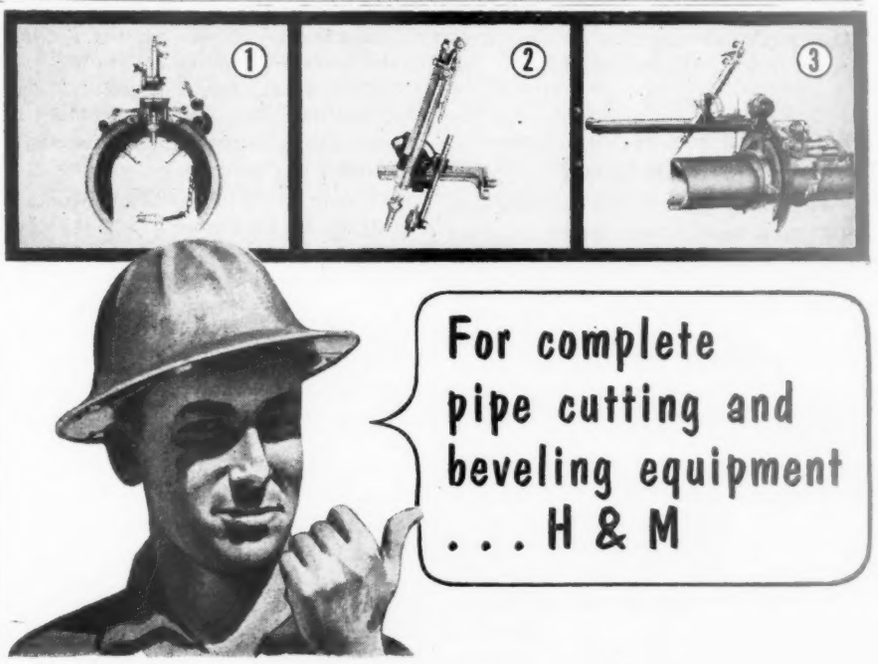
Customary operating practice is to start the piston pump first, taking such suction from one of its own tanks in direct flow. Then one centrifugal pump is started to pump into the suction side of the piston pump, and each additional centrifugal pump is brought into operation in succession.

A check valve in the suction line prevents oil being delivered by the centrifugal pump from diversion into the tank that is providing direct flow to the duplex pump.

The check valve for this tank opens when the tank serving each centrifugal pump is empty, and permits suction to be taken again directly from the tank at the piston pump. Each piston pump is capable of handling the production of four batteries, which may be as much as a mile distant, through the "boost" that it receives from the hook-up with the intermediate centrifugal pumps.

Control is provided by pressure switches, each operated from the discharge side of the centrifugal pump, that shut down the pump when the tank is empty. Dual protection is provided for the piston pumps, by means of a two-stage pressure switch. This switch will shut down the pump when the pressure falls below a pre-set low limit that is reached when the tank is empty, and it will also shut it down when the pressure rises above a pre-set high limit of operating safety.

The Daly field, which contains some 160 wells on production, operates at comparatively low pressures. It is served by rotary gear pumps driven by electric motors. Each pump is fitted with a float switch in the suction line, which is designed to shut the unit down when the tank is empty. To serve low-production batteries that cannot justify the expense of a fixed installation, the pipe line company uses a portable gasoline-driven gear pump mounted on a one-ton truck chassis. The unit may be driven conveniently to any location throughout the field and put into operation within a short time. * * *



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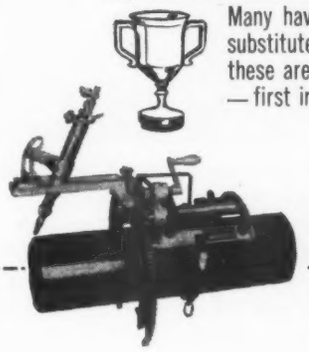
Many have imitated H & M design, but none have found a substitute for H & M quality. Accuracy . . . durability — these are features that are part of the H & M brand. H & M — first in its field . . . and now 40% lighter.



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Pipe Line Projects

South Saskatchewan Extension Okayed

An extension of the South Saskatchewan pipe line has been authorized by the Saskatchewan Department of Mineral Resources. The 8-in. crude line will be 12.8 miles long, connecting the Battrum field north of the Cantuar-Fosterton-Success fields with the present terminal at Cantuar, from where South Saskatchewan Pipe Line Company's 16-in. main line runs to Regina. The maximum capacity of the extension will be 5000 bbl per day.

★ ★ ★

Westward Ho-Sundre Line Applications Deferred

Possibility of a 1955 construction start on a crude line in either direction (north or south) from Westward Ho and Sundre fields in the near-foothills region northwest of Calgary has been killed by the Alberta Conservation Board with its decision to defer consideration of all applications until January 10, 1956, when additional evidence and statistics will be requested from the applicants.

Three applicants have filed for permission to build a line. One would go to Calgary, 65 miles southeast of the fields. The other two would go north, one being proposed to join the present Pembina Pipe Line, Ltd., system and the other to join the Texaco Exploration Company line between Westerose and Edmonton. The latter has considerable spare capacity and has been trying for some time to pick up additional throughput, so far without success.

★ ★ ★

Montana-Wyoming Plans Sale of Line, Facilities

Directors of Montana-Wyoming Gas Pipe Line Company have approved an offer of Montana-Dakota Utilities Company to acquire all the property and assets of Montana-Wyoming, subject to all liabilities. Proposal is subject to Montana-Wyoming stockholder approval at a meeting scheduled for October 11.

Under terms of the offer, Montana-Dakota on December 31, 1955, would exchange 241,577 shares of its common stock for all the outstanding shares of Montana-Wyoming on a share-for-share basis. The Montana-Wyoming directors have declared a 10 per cent stock dividend, which will bring the company's outstanding shares to the 241,577 total.

Montana-Wyoming owns a 340-mile natural gas transmission pipe line and related facilities, running from the Worland field in Wyoming to connect with the Montana-Dakota gas distribution system at a point in eastern Montana. These facilities are leased to and operated by Montana-Dakota.

Contract Awarded on Louisiana Crude Line

Interstate Oil Pipe Line Company has awarded contract to Horton-Schoolcraft Construction Company, Inc., Harvey, Louisiana, for construction of a new crude oil pipe line to the Lake Washington field in Plaquemines Parish, Louisiana. The project will consist of approximately 12 miles of 12-in. trunk line and 7 miles of 4 and 8-in. gathering lines with other related gathering system equipment. Installation will provide initial pipe line service in this immediate area of the southeast Louisiana coastal marshes.

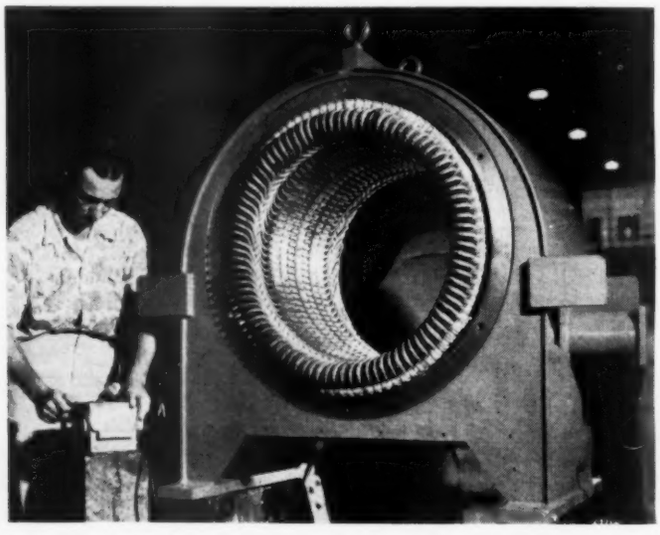
Approximately 10 miles of the trunk line and all of the gathering line will lie under water and the remaining trunk line system will be in the marsh.

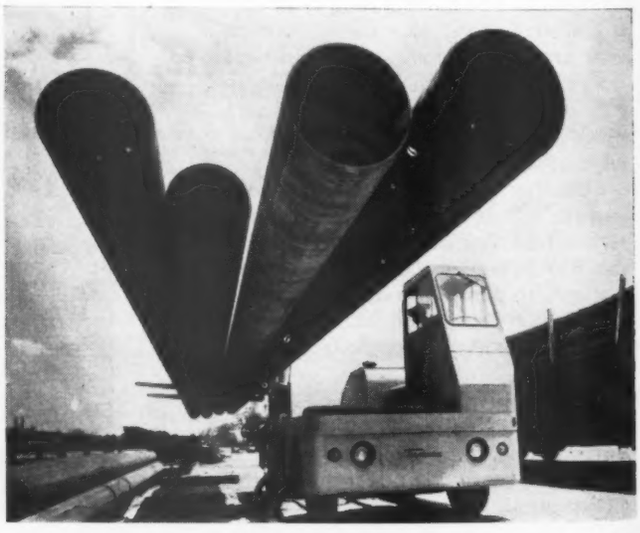
★ ★ ★

Northern Natural Revises 1956 Construction Plans

Northern Natural Gas Company has field application with the FPC to construct facilities for natural gas service in 1956 to 55 communities in Iowa, Minnesota, South Dakota and Wisconsin.

The application supplements one filed earlier proposing to build the Duluth and Aberdeen extensions this year and serve them with natural gas from Canada. Failure by Trans-Canada Pipelines, Ltd., to finance construction





Four silicone-protected motors, left, for driving pipe line pumps, first of their kind to be installed, will go into service next year for Humble Pipe Line at League City, Texas. The weather-protected induction motors, two 500-hp and two 600-hp, will have coils insulated with silicone tapes, rubbers, and varnishes, making them moisture repellant and highly resistant to corrosion. Motor windings will have high heat capacity and metal surfaces will be protected by baked-on silicone finishes. Silicone protection has proved highly effective on the Gulf Coast where equipment is subjected continually to salt air and moisture. Here's a handy piece of equipment, photo at right, — an industrial truck that loads itself while handling several double-random lengths of 30-in. pipe. Called the "Traveloader," it can stack up to 12 ft high, lift a fork truck; carry loads lengthwise and has highway roadability.

of the line which was to bring gas to the International Border prevented Northern from carrying out its Canadian project.

Gas for Northern's 1956 proposed program would come from its present sources of supply in the southwestern United States plus additional supplies that are purchased throughout the year under normal procedure of building up reserves.

Costs of construction in 1956 as shown in the application are expected to total approximately $32,000,000.

Construction costs will be reduced substantially by the proposed use of underground storage near Redfield, Iowa. Northern believes the underground storage will add approximately 50,000,000 cu ft per day to the company's daily capacity during the 1956-1957 heating season.

The 1956 construction program would enable Northern to increase its daily capacity approximately 93,000,000 cu ft. The company's present daily capacity is 1.1 billion cu ft. Presently connected communities would receive approximately 37,000,000 cu ft daily of the capacity. Northern also seeks to serve 12,000,000 cu ft daily to the Allied Chemical & Dye Corporation plant near Omaha.

The construction would include 15 miles of 24-in. to its main line in Nebraska; approximately 28 miles of 24-in. from Ogden, Iowa to the underground storage near Redfield, Iowa; 168 miles of 20-in. line from the Twin City area to Duluth, Minnesota, and Superior, Wisconsin; 92 miles of 12-in. and 71 miles of 10-in. in South Dakota, and 307 miles of branch lines. Horsepower to be added to compressor stations in Texas, Kansas, Nebraska and Iowa would total 12,640.

★ ★ ★

Service Pipe Line Receives 19 Safety Awards

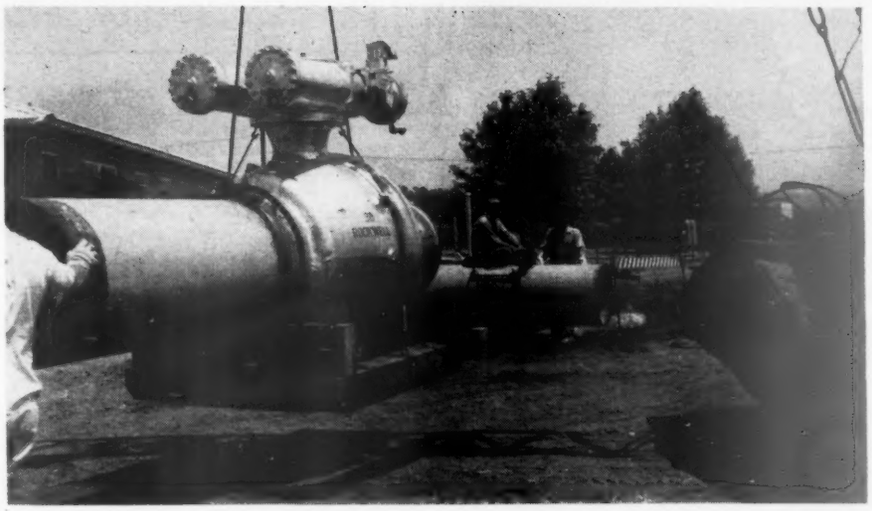
Service Pipe Line Company has been presented 19 awards for outstanding achievement in the field of safety by the API, Joseph A. Holmes Safety Association, and the National Safety Council.

A general company award was presented for the accomplishments of some 2500 employees working 1,118,026 hours between May 24, 1954, and August 12, 1954, without a lost-time accident. All three safety groups recognized this achievement.

★ ★ ★

New Texas Company Terminal

A new Texas Company terminal at Lubbock, Texas, now under construction, will begin operations in early November. To be served by a recently constructed pipe line, the terminal will have a total capacity of 95,750 bbl, provided by eight storage tanks. In addition, terminal facilities include a combination warehouse-office, and tank truck and railroad car loading facilities.



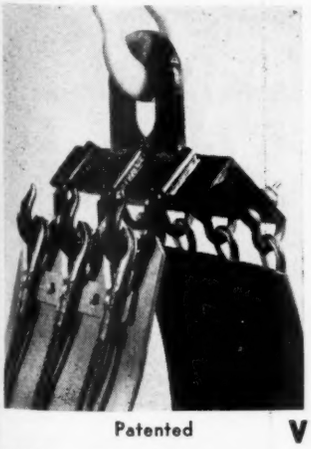
New Valve. The Brea-Olinda pressure limiting station on Southern Counties Gas Company's 30-in. Texas-California pipe line has a new valve — a mammoth full-opening, 30-in. "Hypresphere" Nordstrom valve, which replaces a 24-in. valve. It is being installed for testing and evaluation under actual operating conditions. Equipped with hydraulic operators, the valve will see heavy service at Brea-Olinda, where main line pressure is reduced to 465 psi.

Gas Industry Revenues Up in Second Quarter

Total operating revenues of the gas utility and pipe line industry reached a record high of $4,967,000 for the 12-month period ended June 30, 1955, the American Gas Association reports. This was a gain of $573,000,000, or 13.0 per cent over the $4, 394,000 in the same period a year ago.

Net operating revenues in this 12-month period rose to $655,000,000, a 14.5 per cent increase over the $572,000,000 a year earlier. Net income rose from $441,000,000 to $482,000,000, an increase of 9.3 per cent.

Total taxes paid during the 12 months rose to $621,000,000 from $553,000,000 during the same period a year ago. Total taxes, including federal income taxes, represented 12.5 per cent of operating revenues for the gas industry in the last 12 months.



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New Major Gas Pipe Line Map Issued by FPC

A new five-color, 14 by 20-in. map showing the location of major existing pipe lines, lines under construction, lines authorized but not contracted, and proposed lines — as of June 30, 1955 — has been issued by the Federal Power Commission.

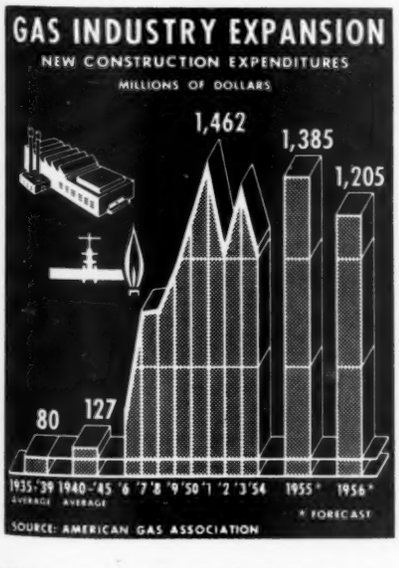
Each line is numbered and refers to an index listing 115 companies. In addition to the pipe lines, the map shows the location of natural gas fields, both major sources and generalized areas of supply. Copies of the map are available from the FPC, Washington 25, D.C., at 25 cents each. Order number is FPC M-44.

Shell Pipe Line Opens New Division in Rockies

Shell Pipe Line Corporation is establishing a new operating division with headquarters at Casper, Wyoming. Designated the Rocky Mountain Division, the new office opened officially October 1.

The division will operate facilities of the Butte Pipe Line Company, now under construction in Eastern Montana and Wyoming, and Shell Pipe Line's wholly-owned facilities in northeastern Colorado. The Butte Line, owned jointly by Shell Oil Company, Murphy Corporation, Placid Oil Company, and Northwestern Improvement Company, a subsidiary of Northern Pacific Railroad, extends from Poplar, Montana, to Fort Laramie and Guernsey, Wyoming.

J. E. Mims, who has been superintendent of Shell Pipe Line's Rancho division with headquarters at Austin, Texas, has been named manager of the new division. Mims, a graduate of Rice Institute, joined Shell in 1942 as a draftsman. He became an engineer in 1946 and later served as superintendent of the firm's Ozark Division at Springfield, Missouri, being made Rancho superintendent, Austin, 1952.



Meetings...

Northeast Regional meeting of the NACE has been set for October 31-November 3 in Niagara Falls, New York. Fifteen technical papers and other events are planned.

Sixth Biennial Permian Basin Corrosion Tour will open on October 12 and continue through October 14. Some 60 exhibits in 3000 square mile area will be visited. Headquarters will be at the Lincoln Hotel, Odessa, Texas.

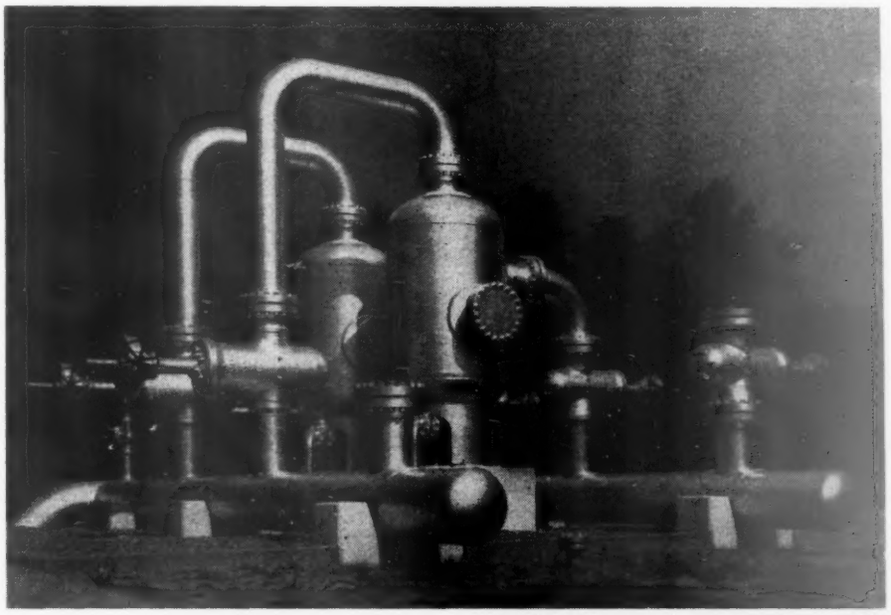
American Gas Association annual convention sites for the next three meetings have been announced by the AGA executive committee. The 1956 meeting will be in Atlantic City, the 1957 meeting in St. Louis, Missouri, and the 1958 meeting at Atlantic City.

NACE Annual Conferences and Exposition dates for the next four years have been announced as follows: 1956, New York City; 1957, St. Louis; 1958, San Francisco; and 1959, Chicago.

3rd Gas Measurement Institute, sponsored by the University of Kansas and Southwest Kansas Petroleum Industry, is scheduled for October 3-4 at Legion Hall, Liberal, Kansas.

43rd National Safety Congress and Exposition will be held in Chicago on October 17-21. Sessions on safety in the petroleum industry are scheduled for the Conrad Hilton Hotel.

South Central Regional meeting of the National Association of Corrosion Engineers will be held October 18-21 in the Shamrock-Hilton Hotel, Houston, Texas. Pipe line group discussions are slated for Friday, October 21.



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Aerotec Gas Scrubbers are noted for their ability to deliver gas, free of fluid carryover. No liquids used in the scrubbing process makes this possible. Temporary overloads of up to 100% are easily handled without efficiency loss.

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PIPE LINE PERSONALS

▸ **E. E. Miller** and **E. S. Murray** were elected vice presidents of Tennessee Gas Transmission Company by the natural gas pipe line firm's board of directors recently.

Miller, who had been general superintendent of operations, has been assigned to the sales department. Murray, formerly chief engineer, was designated general superintendent.

Sydney S. Bailey, eastern sales manager with offices in New York, was made sales manager. **L. W. A. Campbell,** assistant chief engineer, was promoted to chief engineer. **Joseph L. Parrish, Jr.,** supervising engineer, and **T. K. Davis,** superintendent of gas control, were named assistant general superintendents.

Both Miller and Murray were experienced pipe line engineers when they joined Tennessee Gas in its formative years. Miller came with the company in 1944 and Murray joined the company in 1943.

Bailey came with the company in 1951 and has been eastern sales manager since 1954.. Campbell joined the company as an engineer in 1947 and became assistant chief engineer in 1954. Parrish has been with the company since 1947, becoming supervising engineer in 1955. Davis joined Tennessee Gas as a dispatcher in 1946 and became superintendent of gas control in 1951.

E. E. Miller

E. S. Murray

S. S. Bailey

L. W. A. Campbell

▸ **William T. Eskew, Jr.** has been appointed chief engineer, headquarters Los Angeles, for Southern Pacific Pipe Lines, Inc.

▸ **Malcolm E. Powell,** superintendent of Magnolia Pipe Line Company's western division at Midland, Texas, will be advanced to assistant general superintendent of the company with headquarters in the Dallas, Texas, general offices. Powell attended Southern Methodist University. He began his career with Magnolia in 1931, and was promoted to a district gager. In 1949 he became superintendent of the western division with headquarters at Midland.

Succeeding Powell as division superintendent at Midland will be **J. R. Wright,** who has been assistant superintendent of the southern division with headquarters at Houston. Wright, who attended Lamar College began his service with Magnolia in 1931, as a pipeliner in East Texas. After several years as station engineer, field gager and chief gager in various oil fields in Texas and Illinois, he was promoted to assistant superintendent of the North Basin district in West Texas and then to superintendent of the Beaumont Pipe Line district.

Roland E. McDonald has been advanced from superintendent of Magnolia's Southwest Texas district with headquarters at Alice, to assistant division superintendent at Houston. After attending Texas A. & M. College, McDonald was employed by Magnolia in 1926 as a material man. In 1951 he was named district superintendent with headquarters at Alice.

Homer Cranfill, chief gager for North Texas and Southern Oklahoma, will be promoted to superintendent of the Southwest Texas district at Alice. Cranfill began working with Magnolia in 1928, in a pipe line gang at Iatan. He was made chief gager for the southern division in 1950, at Alice.

C. R. Smith, chief gager in Magnolia Pipe Line Company's western division with headquarters at Midland, has been transferred to Wichita Falls to succeed Cranfill. **Arnold Balke,** gager foreman for the Midland gathering system, will be promoted to chief gager for the western division at Midland, and **H. C. Minyard,** field gager in the Healdton gathering system is being advanced to gager foreman for the Midland gathering system with headquarters in Magnolia's Pegasus field in Midland County, West Texas.

▸ **D. M. Morrison** was elected president of Trans Mountain Oil Pipe Line Company at a meeting of the board of directors in Vancouver, recently. He is from Shell Oil Company of Canada, Limited, where he was vice president — manufacturing.

D. M. Morrison

Morrison was graduated from the University of British Columbia with a B.Sc. in chemical engineering.

▸ **W. W. Bredlow,** superintendent of Standard Oil Company (Indiana) Moorhead, Minnesota, products pipe line terminal, has been transferred to Superior, Wisconsin, as superintendent of the marine terminal there.

K. L. Emery, chief clerk of the Moorhead terminal, has succeeded Bredlow.

Bredlow, a native of Chicago who attended Purdue University, joined Standard in 1946 as assistant terminal superintendent at Moorhead. He became superintendent in 1948. During 1953 and most of 1954 he served as project engineer in charge of construction of Standard's temporary pipeline terminal at Mandan, North Dakota, and its terminal at Jamestown, North Dakota.

▸ **Clifford O. Nielson** has been promoted to division chief engineer for the Service Pipe Line Company's Kansas division.

Nielson majored in civil engineering while in college. He worked for the Kansas Highway Commission before joining Service Pipe Line Company in 1941. Starting as an instrument man, he advanced to engineer in 1948. He has been headquartered at Wichita since 1950.

Lars C. Jensen, Service Pipe Line division coordinator, Nebraska division, has been transferred to the Kansas division with headquarters in Wichita. Jensen joined Service Pipe Line in 1940, as a laborer. In 1946, he was appointed material and time supervisor and in 1949, was made area coordinator for the Nebraska division with headquarters at Topeka.

▸ **Edward A. Livingstone,** vice president of Babcock & Wilcox Company, has been named director of Columbia Gas System, Inc. He will also be a director of Manufacturers Light & Heat Company of Pittsburgh, a subsidiary.

▸ **P. E. Behr** has been named secretary of Alabama Gas Corporation. He succeeds the late R. C. Wirtz.

▸ **S. Lloyd Nemeyer** has been named president and director of Milwaukee Gas Light Company. He replaces **Dudley B. W. Brown,** who has resigned to become vice president and secretary of American Natural Gas Company.

J. L. Parrish, Jr.

T. K. Davis

M. E. Powell

J. R. Wright

R. E. McDonald

H. Cranfill

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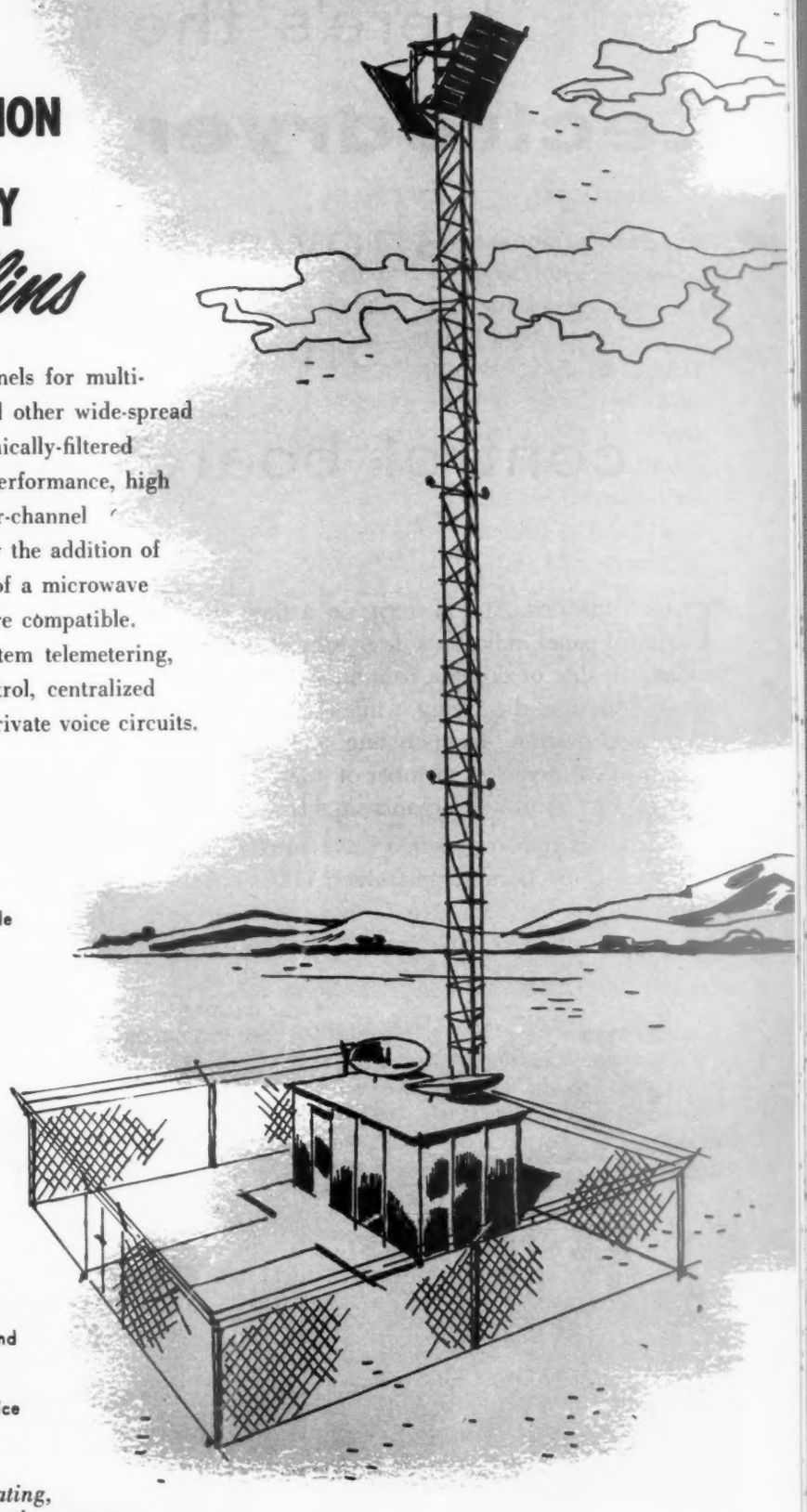

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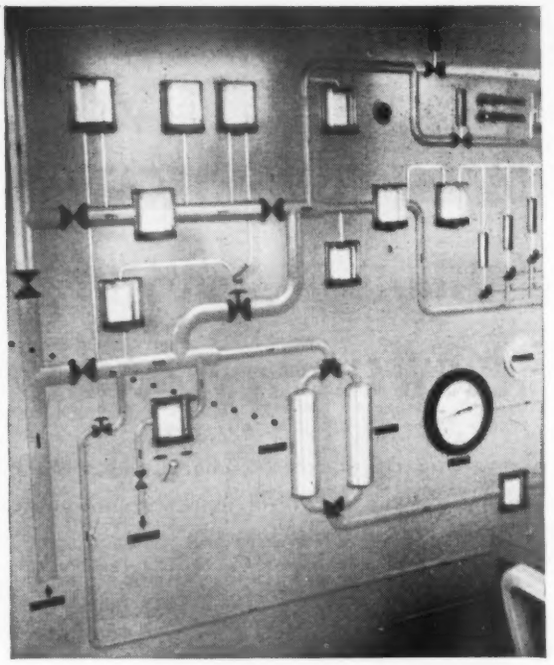
Here's the **Lectrodryer** shown ⬡ on this control board



THIS TWIN-COLUMN SYMBOL on a flow chart or control panel indicates a drier located here in the process, capable of doing a continuous DRYing job. One column does the drying, while the other is being regenerated by heat. To many engineers this symbol means a Lectrodryer*, a member of a large family of driers for air, gases and organic liquids.

Instruments and air-operated valves are kept working smoothly by Lectrodryers which DRY the compressed air fed to them. No freeze-ups where air lines run out-of-doors. No formation of mud or rust to clog delicate instrument ports.

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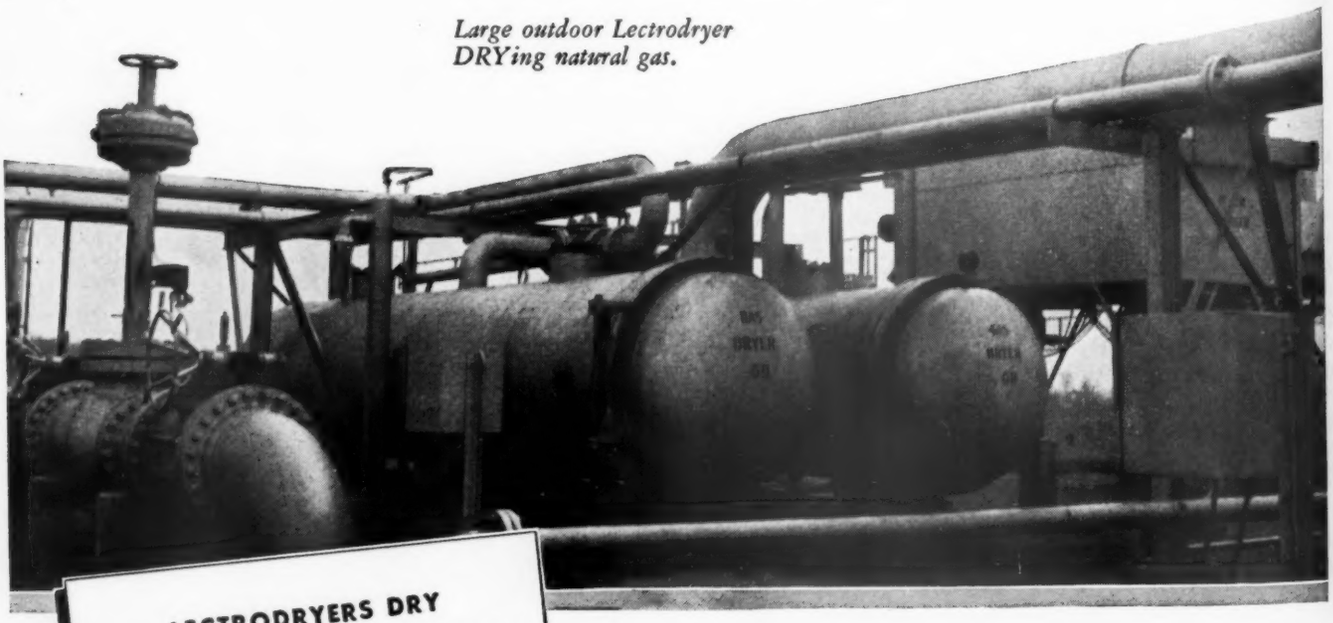
The book, *Because Moisture Isn't Pink,* pictures many installations. For a free copy, write Pittsburgh Lectrotype Corporation, 334 32nd Street, Pitts-30, Pennsylvania.

Large outdoor Lectrodryer DRYing natural gas.



LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

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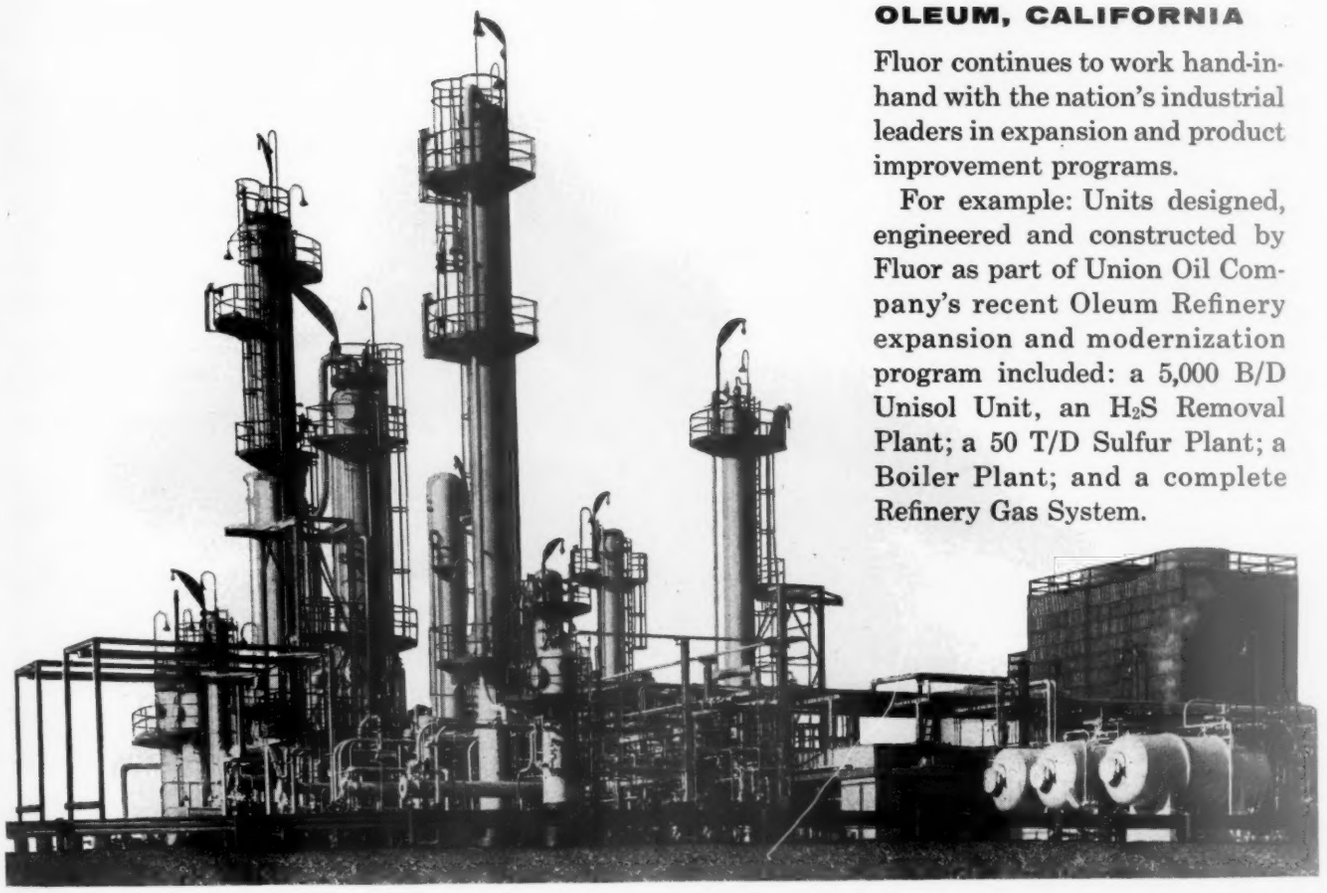

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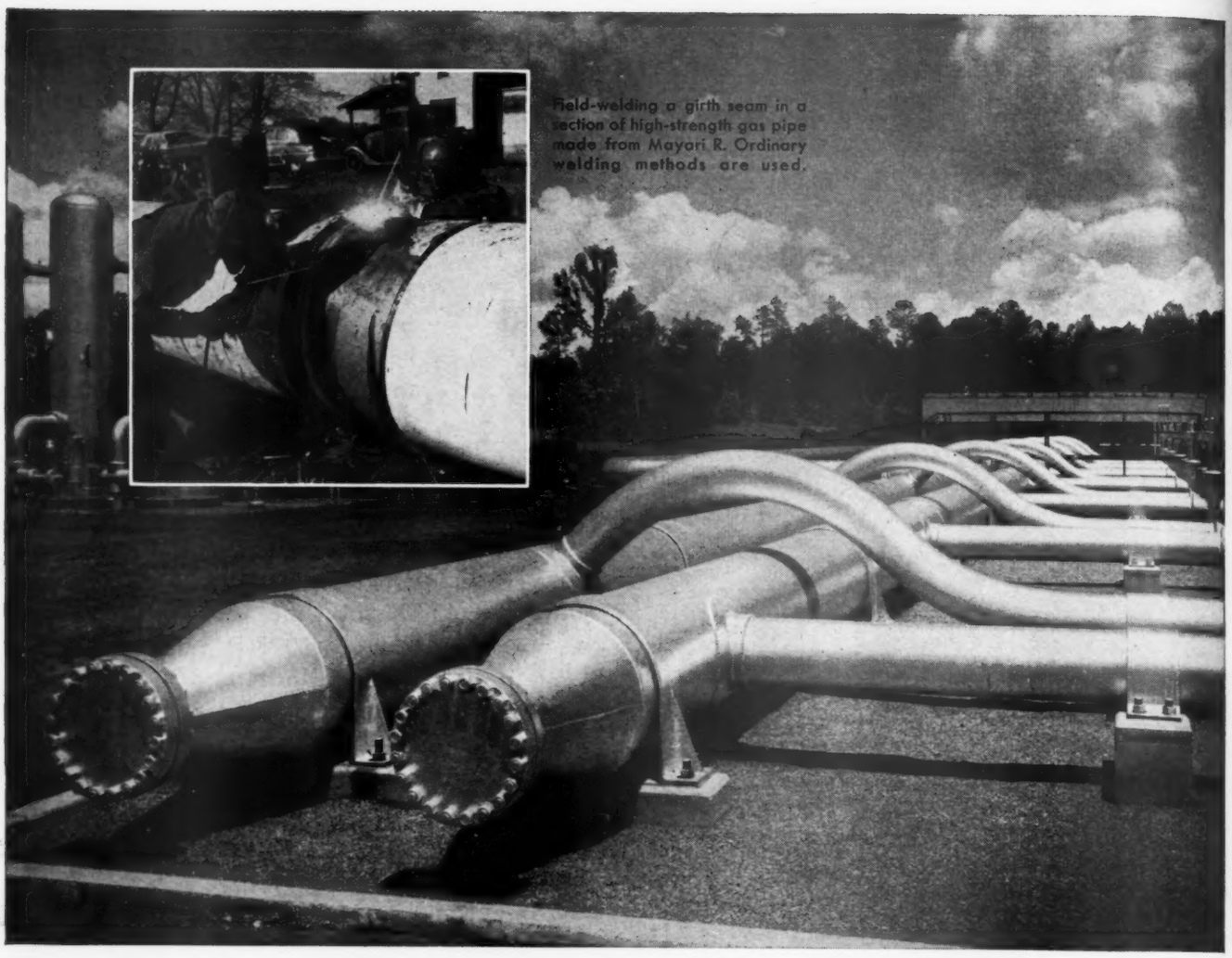

Field-welding a girth seam in a section of high-strength gas pipe made from Mayari R. Ordinary welding methods are used.

The 30-inch pipe, header tees and swages shown above were all fabricated from Mayari R, Bethlehem's high-strength, low-alloy steel.

This high-strength pipe is easy to weld

Pipe made from Mayari R—Bethlehem's high-strength, low-alloy steel—has welding properties equal or superior to those of other pipe having the same load-carrying capacity. Simply follow your usual field-welding practices, using ordinary mild-steel rods. The weld metal will pick up enough alloy content to match the Mayari R's high mechanical properties. Under normal conditions, there's no need to preheat unless the pipe walls exceed ¾ in.

Resists Fatigue—Mayari R steel combines high-strength with extreme ductility. Its physical properties include a yield point of 50,000 psi min; ultimate tensile strength of 70,000 psi min; and an unusually high endurance limit of 60 to 70 pct of the tensile strength. As a result, pipe fabricated from Mayari R has the ductility, resistance to fatigue and the impact qualities needed to handle vibration and other severe stresses encountered at compressor stations.

Savings of Materials and Money—Due to its superior mechanical properties, high-strength gas pipe made from Mayari R may be used in lighter wall thicknesses than ordinary carbon-steel pipe.

Ask the nearest Bethlehem sales office for complete information about Bethlehem Oil and Gas Pipe, whether made of high-strength Mayari R, or ordinary carbon steel meeting ASTM A134 and API 5LX42.

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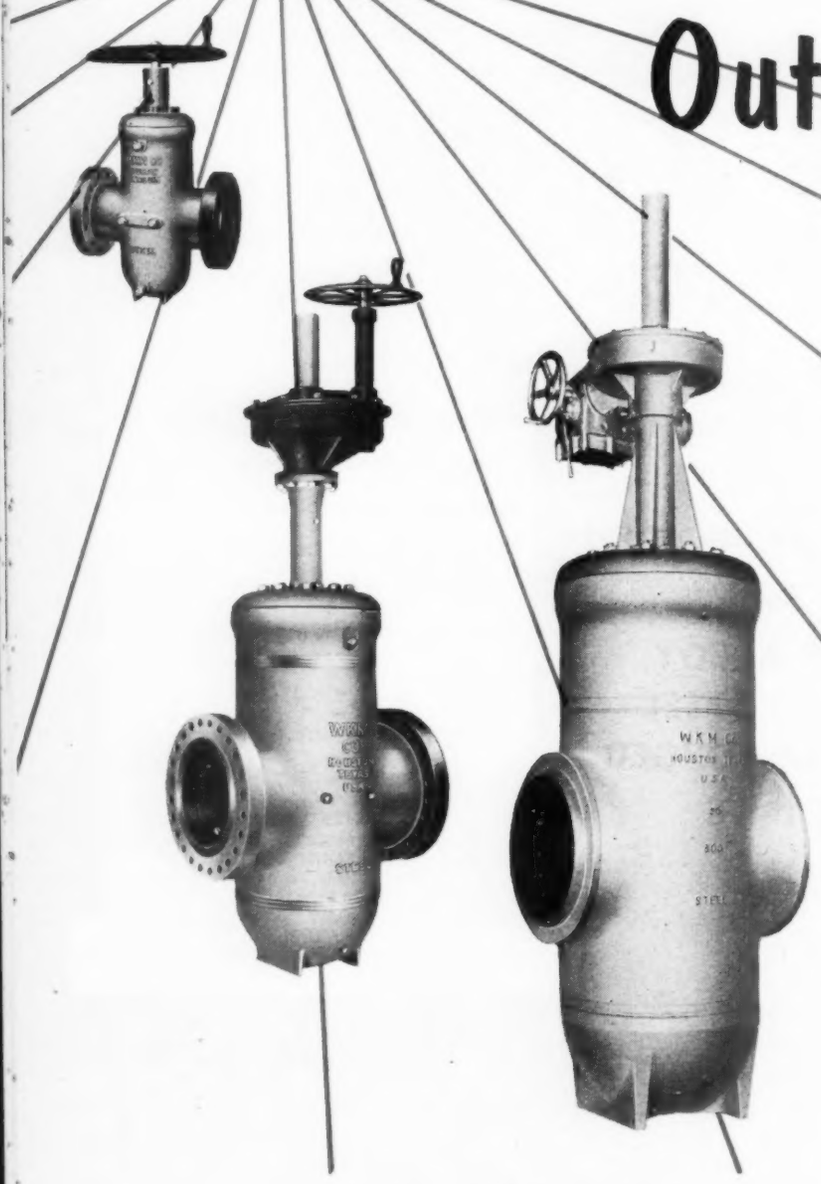

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Prompt Delivery: Kellogg's plant modernization program assures faster delivery than ever before. Small and large orders receive the same attention.

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Guaranteed Performance: Kellogg's reputation has been built on long and efficient product life. The MWK name plate is your guarantee.

FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.

In Canada: The Canadian Kellogg Company, Limited, Toronto • In Europe: Kellogg International Corporation, London

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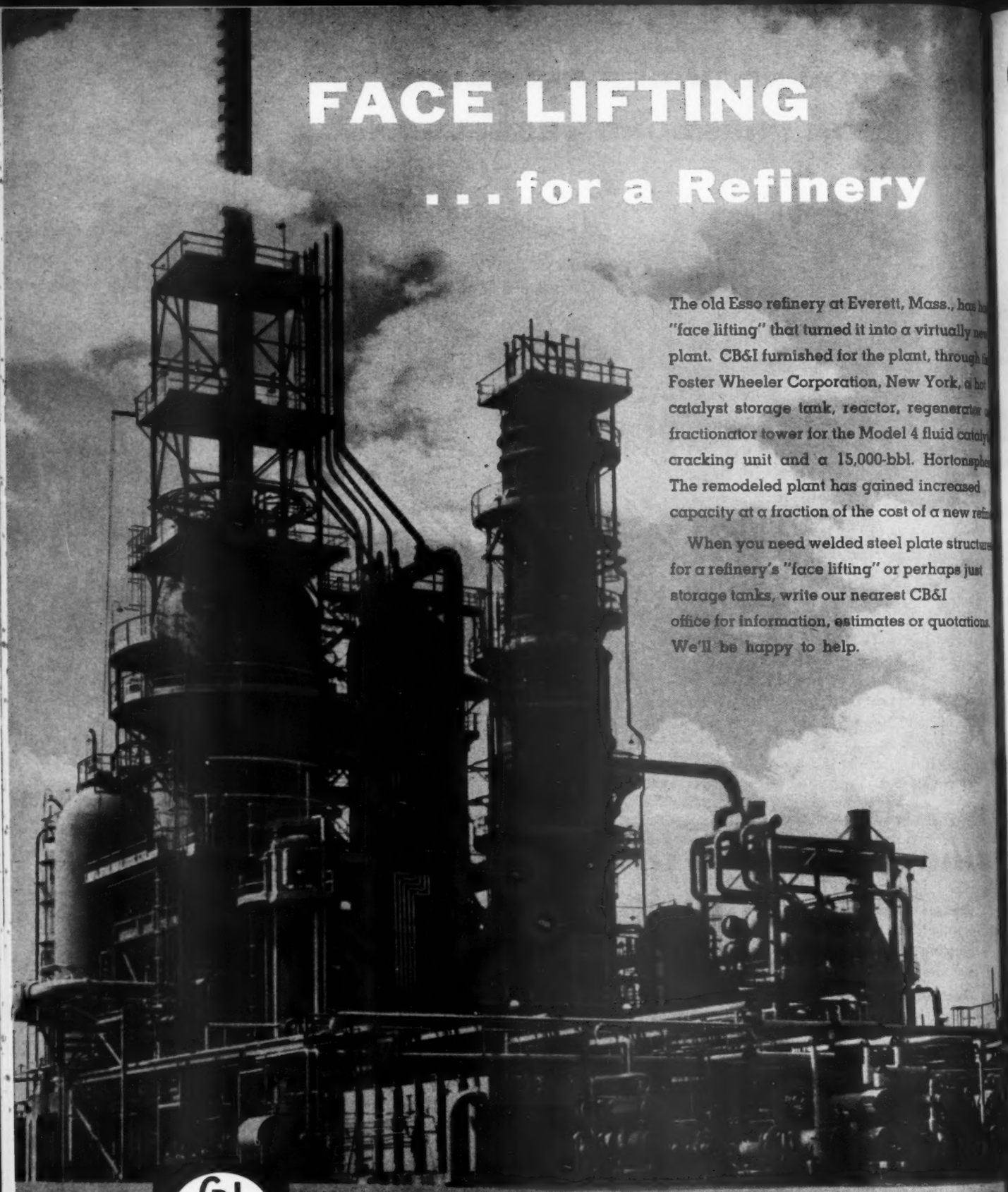
*Trademark of The M. W. Kellogg Company

PUT YOUR PROBLEMS UP TO M KELLOGG W


FACE LIFTING
. . . for a Refinery
The old Esso refinery at Everett, Mass., has h
"face lifting" that turned it into a virtually ne
plant. CB&I furnished for the plant, through t
Foster Wheeler Corporation, New York, a hot
catalyst storage tank, reactor, regenerator
fractionator tower for the Model 4 fluid catal
cracking unit and a 15,000-bbl. Hortonsph
The remodeled plant has gained increased
capacity at a fraction of the cost of a new refi
When you need welded steel plate structure
for a refinery's "face lifting" or perhaps just
storage tanks, write our nearest CB&I
office for information, estimates or quotations.
We'll be happy to help.
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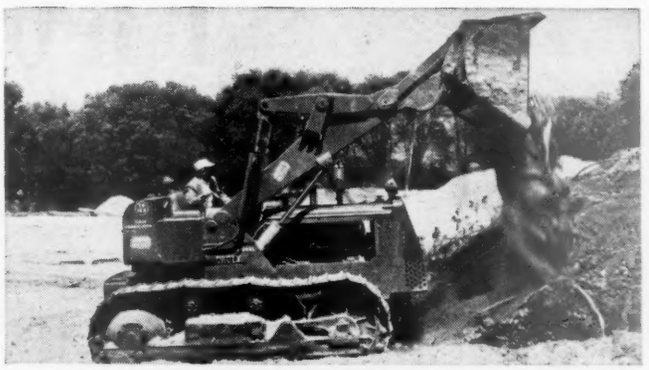
OWNERS REPORT THE DECISIVE DIFFERENCE IN NEW

TD-18A Performance

"It can self-load and deliver fastest" "International TD-18A improvements like the new 300% stronger track frames and cartridge-type roller seals increase production, machine life, and operating ease. As for power, our new TD-18A can self-load the 8-11 cubic yard scraper and deliver fastest of any crawler we ever had." *Here's proof extra traction matches the TD-18's power increase!* G. W. Owen, McDonough, Ga.



"Every load's a payload" "My TD-18A International Drott is built for the operator's comfort. I know, because I'm the operator. It has 360° visibility which no other loader has. Every load is a payload." *No other outfit built gives you the TD-18's combination of power, visibility and responsive controls.* V. S. Steffes, Owner, Earthmoving and Clearing, Batavia, Illinois.

"Operators fight for new TD-18A!" "The TD-18A's were always good—fast, trouble-free performance and low operating cost made me money. The new model TD-18A is stronger and really planned for the man in the seat. It has operators fighting for it." Big, wide, comfortable cushions; hydraulic steering control boosters, and levers, conveniently grouped on the roomy, non-skid deck! *No wonder TD-18A handling ease turns "skinners" into high-producing operators throughout the day!* M. B. McKee, McKee Construction Co., Chickasha, Oklahoma.

"Uranium search toughest of all!" "I'm in the hardest work I know of—building roads into uranium claims, rim-cutting development work. The TD-18 we used for six years had the motor overhauled after five years, and when we traded a year later the transmission and drives were still original equipment. I believe this heavied-up new model TD-18A is by far the best of all." *Advances like the new bridge-strong welded track frames, stronger transmission and exclusive cartridge-type track roller seals back his judgment.* O. Frost Black, Owner, Blanding, Utah.

Ease into the foam-rubber-padded, panoramic-vision seat and see the *decisive difference*. Try new finger-tip power steering, and other big *job-easing incentives* for boosting production, as developed only by International. Prove TD-18A *full-power traction*—note, too, how the gear train is beefed-up to transmit 103 drawbar hp, and then some! Measure what new *300% stronger track frames* mean *for full-capacity performance* under slam-bang conditions. Compare how new *cartridge-type track roller seals*, and other International *downtime-prevention engineering*, beat anything else on tracks. Ask for a new TD-18A demonstration!

INTERNATIONAL HARVESTER

INTERNATIONAL®

INDUSTRIAL POWER

MAKES EVERY LOAD A PAYLOAD

XUM

P 926.1

MANAGEMENT'S REAL JOB

PROFITS

Edward J. Burnell*

THE management of an enterprise is an exacting and many-sided task which requires constant attention to organization, the development of executives, directing current operations, and planning for the future. The planning side of management has become particularly important to business success in recent years, because large capital investments, commitments to personnel and long-range research expenditures all have a considerable time lag before payout.

Management has, therefore, spent increasing time and effort trying to improve its planning and its projections into the future. In these efforts, management has frequently teamed up with consultants who provide time and skill to assist in this exacting task. As a result, management consultants have a natural inclination to be forward-looking and planning-minded.

With this background, you will quickly perceive what a turn-about it is for me—as a management consultant who has devoted a major share of my time, interest and energy to this important and demanding task of long range planning—to say that planning is all well and good, but beware!

It is very well to focus attention upon the development of new markets and upon technological product improvements to serve these markets. It is all very well to concentrate high level attention on nurturing the next generation of management. It is all very well to plan for strategic plant locations, formulate capital budgets, and set up an equipment replacement program to assure your efficiency.

But planning comes second—after you have assured a current profit. You first have to eat, today and tomorrow. You have to do business, sell merchandise, make or buy your product line, and show profits every step of the way. You not only need a profit, but a profit plus the means to finance the planning activity and the programs it generates. The foundation of meaningful planning for tomorrow must be the solid accomplishment of today's task — running the present business competently.

Once you have the profits, you may then look forward to using them wisely. This is where planning comes in, and planning requires courage. It takes a foresighted and a courageous man to invest hard-earned profits in tangible property. It takes an even bolder man to invest them in sheer ideas. But ideas are where enterprises start, and from them are reared buildings and factories and jobs across the land.

New ideas we must have to give us direction toward a better world, and plans to give us milestones to measure our accomplishment. But driving attention to operations is what keeps us going down the road, and profit measures the distance traveled.

I believe that these considerations demonstrate that ample current profits are the first and foremost concern of management.

*Booz, Allen & Hamilton, Management Consultants, Chicago, Illinois.

EXCLUSIVE Planning must await income — you can't invest in new ideas, new buildings, new factories, and new employees until receipts are ahead of expense.

Increasing Profitability

At this point the reaction may be similar to a business acquaintance of mine when I was talking to him in this vein. He said:

"You don't have to twist my arm. I am not adverse to making profit. In fact, I have been trying to do that all my business life. The question in my mind is not whether to make a good profit, it is how."

Although a few businesses here and there have a lucky break, there is no magic to making a profit. It is only done by a lot of drive, hard work, and organizing ability. Every businessman knows this. You have to put your house in order by attention to today's activities.

You must start with what you have and address your attention to how to do it better, bringing to this process an open mind and a forceful determination that much can be done. Our experience in hundreds of companies incontestibly proves that opportunity for improvement exists even in the very best managed ones.

Let's take a closer look at the elements of day-to-day operations and profit making which invite attention. While there are many places to look, there is no alternative to a close and careful examination of each segment of your operations, piece by piece. Here are 70 places — 70 different nooks and crannies where management can do some cleaning up. We call them the key factors of business. They are part of our management audit. Whenever we take on a general audit of management we take a hard look at each of these items insofar as they are pertinent to a specific situation. In fact, you have to bear down on each of these aspects of your business regularly if you are to keep organized, make a profit, and have time to look ahead.

(See Table On Page E-6)

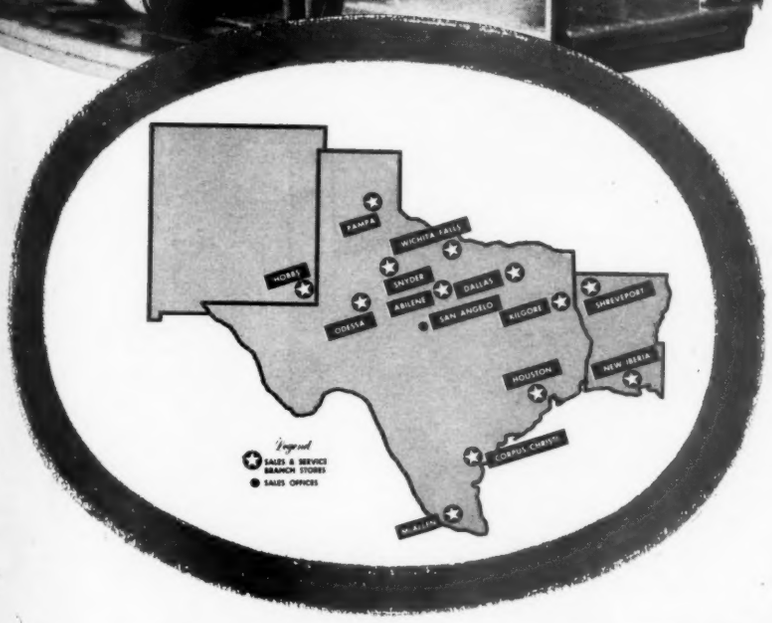
WAUKESHAS LRZB'S Power

Durham's new Ideco

Super 7-11

When Durham Drilling Co. installed its new Ideco Super 7-11 rotary drilling unit three Waukesha engines were chosen to provide dependable, economical power. And like every Waukesha engine in the field, these engines are backed up by Waukesha Sales & Service, Inc.

Waukesha Sales & Service has branches throughout Texas, Louisiana and New Mexico located close to the heart of oil activity to provide prompt service and prevent losses from unnecessary down-time. Waukesha Sales & Service, Inc. has the experience and the facilities to give your Waukesha engine the service it needs to stay in first class condition.



WAUKESHA

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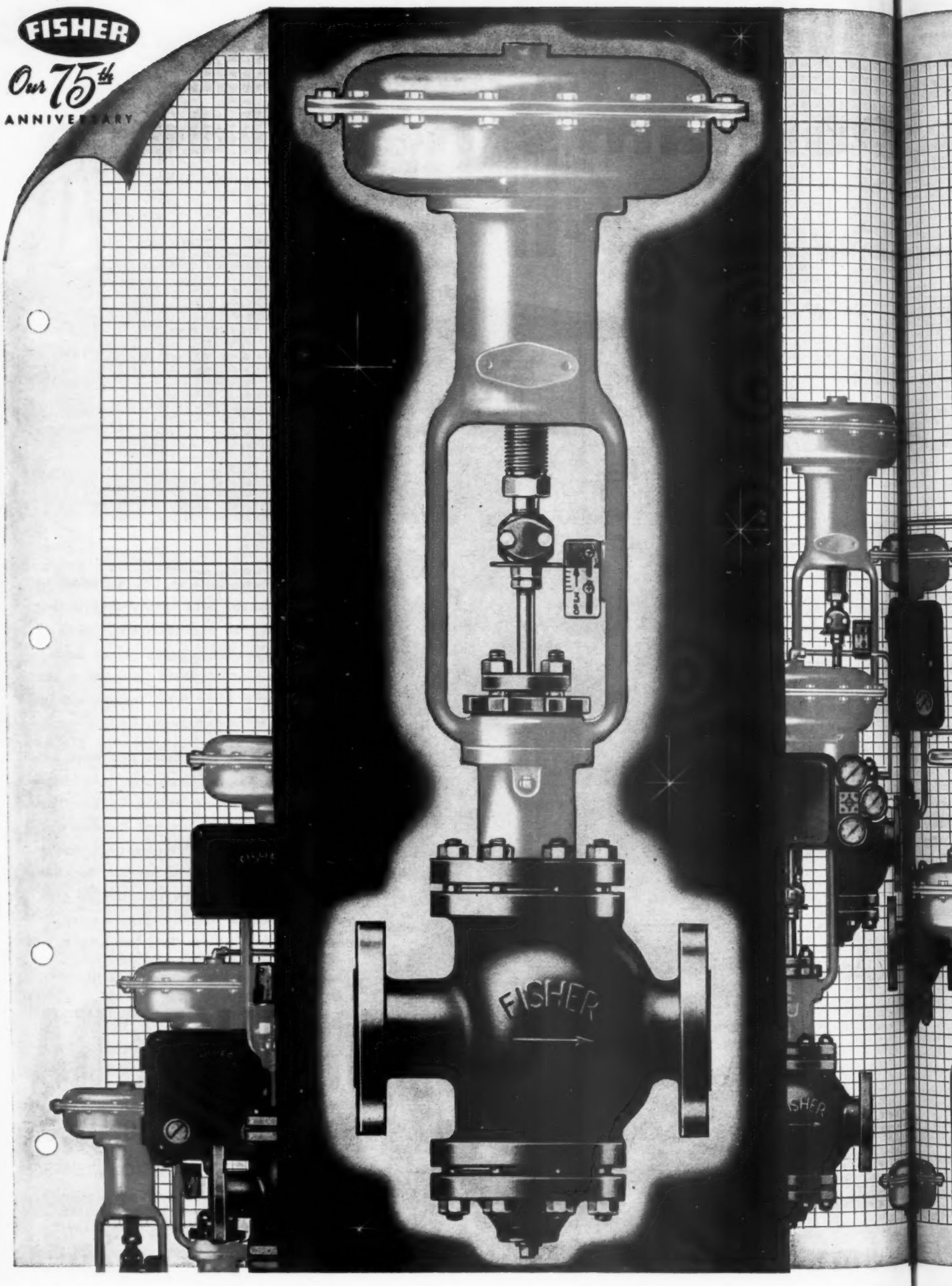
EXCLUSIVE DISTRIBUTORS FOR WAUKESHA PRODUCTS IN TEXAS, NORTH AND WESTERN LOUISIANA, SOUTHERN ARKANSAS AND NEW MEXICO

WORLD'S LARGEST DISTRIBUTOR OF OIL FIELD ENGINES

To obtain more information on products advertised see page E-51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FISHER®

Presents An Improved

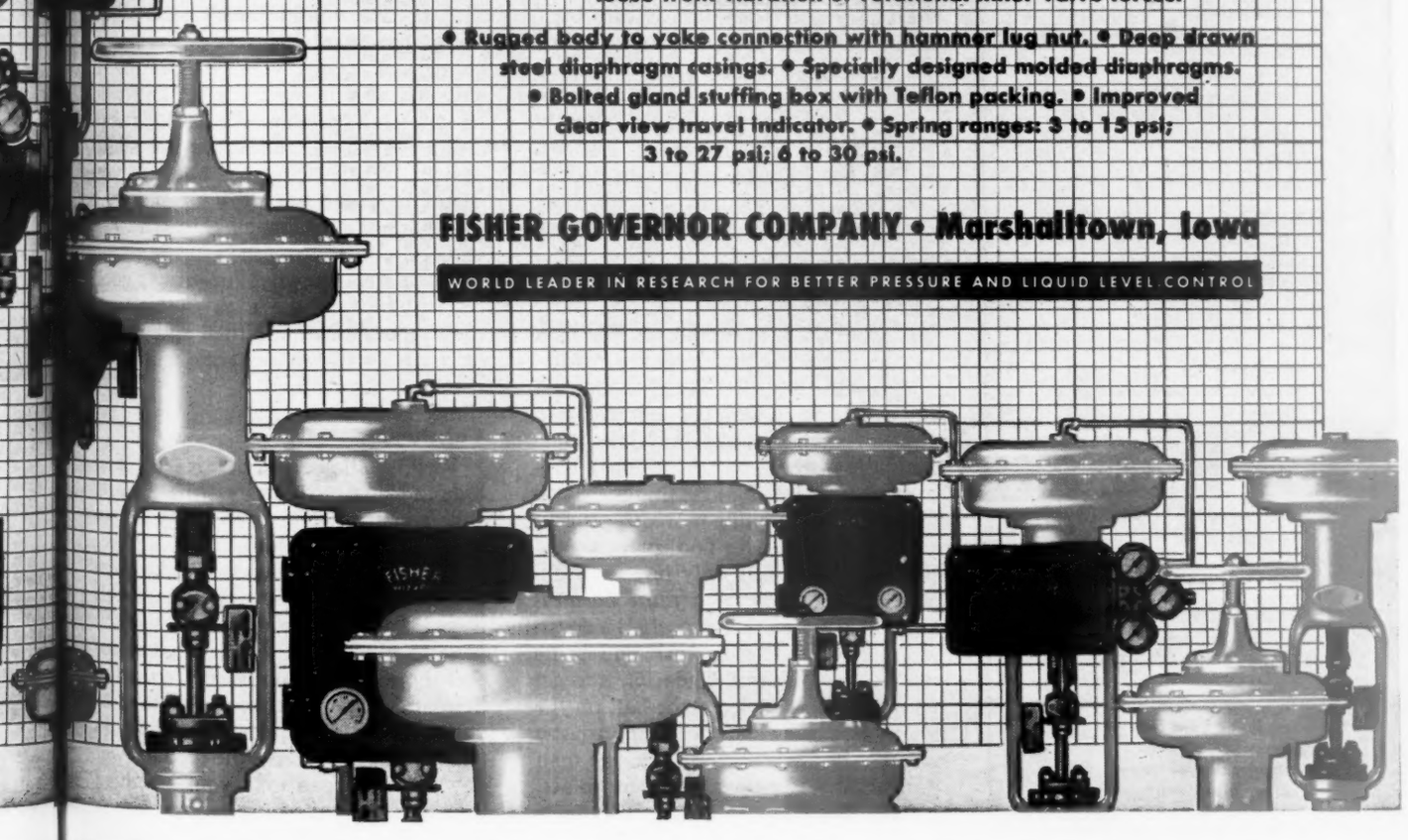
DIAPHRAGM MOTOR VALVE OPERATOR

Bolted-clamp type stem connection. This allows large latitude in valve stroke adjustment. It can be disconnected in the field without damage to the stem. It will not shake loose from vibration or rotational inner valve forces.

• Rugged body to yoke connection with hammer lug nut. • Deep drawn steel diaphragm casings. • Specially designed molded diaphragms. • Bolted gland stuffing box with Teflon packing. • Improved clear view travel indicator. • Spring ranges: 3 to 15 psi; 3 to 27 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL



XUM

KEY FACTORS OF BUSINESS

ADMINISTRATION AND FINANCE
- Objectives
- Corporate Structure
- Policies
- Planning
- Capital
- Management
- Organization
- Management Control
- Facilities
- Investments
- Public Relations
- Patents and Trademarks
- Executive Compensation

PRODUCT ENGINEERING AND RESEARCH AND DEVELOPMENT
- Fundamental Research
- Product Research
- Product Development and Engineering
- Specifications
- Technical Services

MANUFACTURING
- Production
- Materials
- Processes
- Machinery and Equipment
- Building and Grounds
- Power and Utilities
- Supervision
- Production Control
- Purchasing
- Materials Handling
- Quality Control
- Man Methods
- Time Standards and Wage Incentives
- Cost Control
- Traffic

SALES
- Product Lines
- Markets
- Customers
- Competition
- Distribution Methods
- Prices
- Sales Control
- Advertising and Sales Promotion
- Order Handling
- Sales Training
- Sales Compensation

ACCOUNTING AND CONTROL
- Accounting
- Procedures
- Office Methods
- Payroll
- Inventories
- Payables
- Insurance
- Credits and Collection
- Billing
- Receivables
- Office Services
- Taxes
- Costs
- Standards
- Budgets
- Reports
- Internal Auditing

PERSONNEL ADMINISTRATION
- Wages and Salaries
- Hours
- Employment
- Training
- Employee Relations
- Personnel Records
- Benefits and Services
- Safety and Health

Here are the 70 places where management can clean up day-to-day operations — to help make a profit so it will be possible to make a program for the future.

Method to Profit Making

So much for where — now the method, no secrets barred—we are glad to give away the ideas in our consultants' handbook. We could probably spend most of the day on how you go about checking up in each of these seventy phases of management. Under each one a series of pentrating and specific questions can be developed. The basic method, however, is to get the real answers to the what and why in each operation, then do some thinking.

To keep it short and simple, there are four essential steps to improve your operations and profits:

- **You use analysis.**
- **You use a sense of urgency.**
- **You use people.**
- **You use follow-up.**

Using analysis means getting the facts, not just the facts that people tell you—but what they don't tell you and what they don't know. Analysis means penetration, going at a management operation from every side, questioning everyone and everything in a friendly but hard-nosed way. A good place to start is to ask your people, and yourself, what you are trying to accomplish in this particular operation. Then follow this up with a liberal dose of why? why? why? You'll be surprised how much people know that "just ain't so." You'll be even more surprised at how many ideas people have for doing their job better if you can get them to tell you about them.

The next step, when you get all the facts, is to crystallize a decision. I call this using a sense of urgency. You have to decide upon actions that are positive and specific and that these actions are important to undertake immediately. Lots of people make decisions right and left—on the wrong things. Urgency means putting first things first. It also means something more, to get people to agree to act. Too many executives think there is only one right answer—their answer. In most business situations there are usually half a dozen alternatives that will work and bring the results you want. The trick is to get your people to pick up the ball on the alternative they can feel enthusiastic about. Although decision is a one man crucial part of motivating them to act.

That brings me to people. You have to use the people in your organization, and they are the ones who are going to keep the shop tidy while you do your planning. So they have to know what to do. Their job must be clearly understood, their place in the organization settled. You don't want them busting in on you to ask whom they report a broken widget to, just when you are solving the market potential in 1970 of experimental product X44 that the laboratory expects to go to work on next week. When you are thinking out front, you want to stay out front. So tell your people today what they are supposed to do, what performance is expected of them, what they can decide on their own, who they clear with when in doubt. This takes some thinking through—but you aren't going to get a chance to think about much else until it is done.

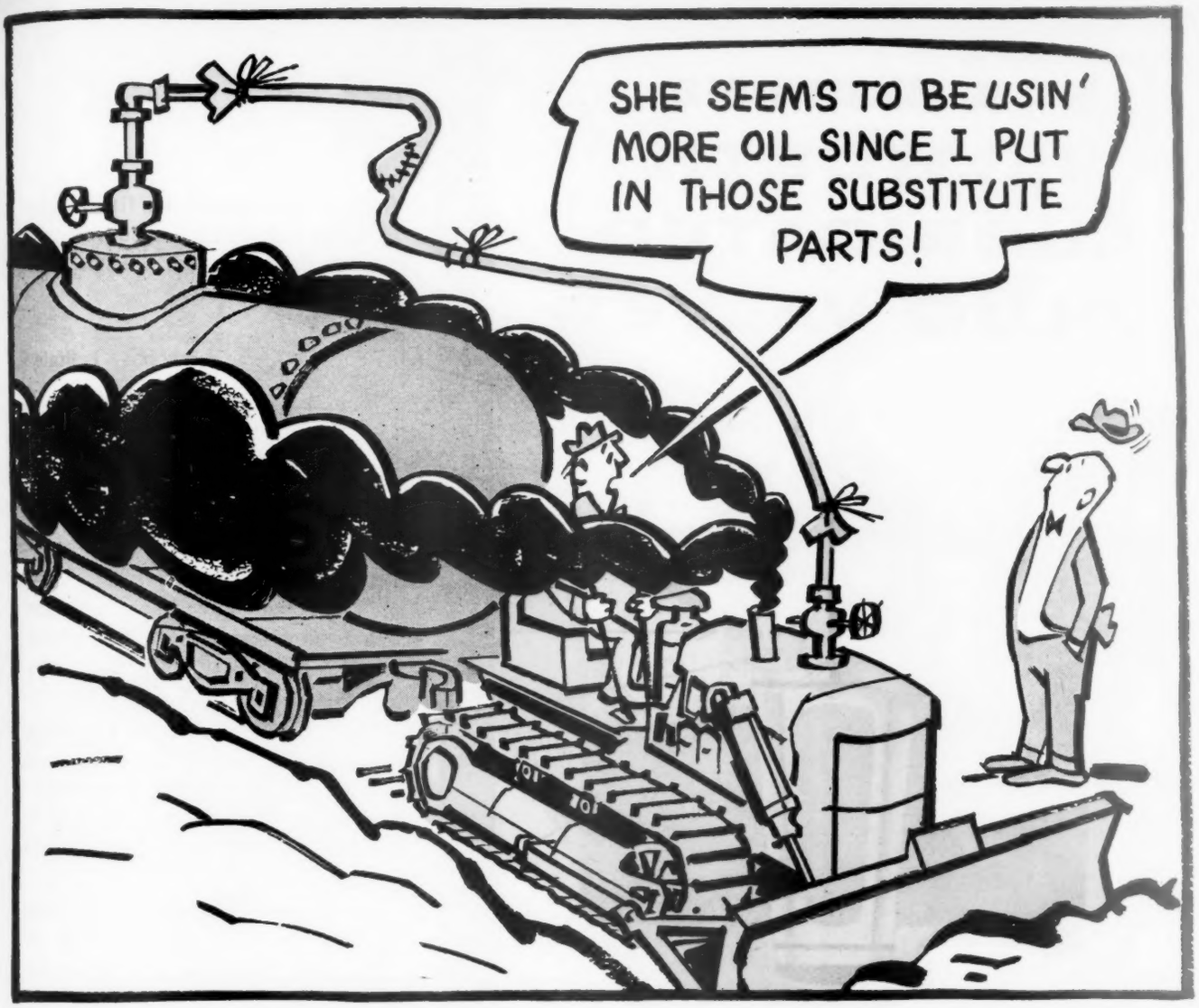
Lastly, you use a follow-up system. This means that you have to catalog:

What you want to get done,
Who is going to do it,
When it should be checked on, and
Who is going to do the checking and report back to you.

To carry out a specific follow-up, you need a continuing system of information that tells you when something goes wrong, where it is wrong, if possible why it went wrong, and who to talk to to fix it up. We call this control information. It's like a fire alarm system. When things get hot and you ought to come out of your planning tower, the bells start ringing. The key to good control or follow-up is to pin down in advance what constitutes good performance in the eyes of management, measure it, and then spread this information out to everyone who must use it.

Conclusion

Well, gentlemen, that's it—the prelude to planning; it's a lot of hard work. But it can be fun, too, if you like to give out man-size jobs, motivate people to tackle them, see men take them over and succeed, and watch the wheels hum. My only admonition is that you have to like people well enough to see that the methods I outlined are used to help and inspire people rather than to curb and criticize them. If you can do this in any business, the profits will flow and you can take your planning leap into the wide blue yonder. * *



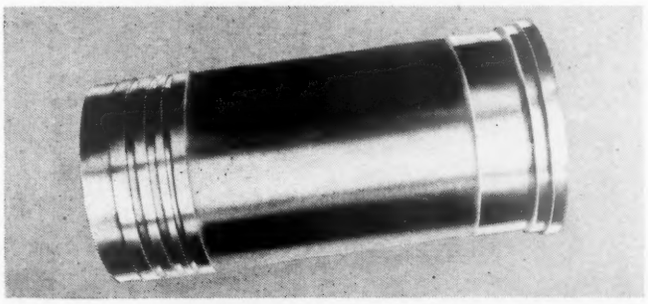
Chances are you'll never need to hook on a tank car to avoid down time. Chances are you *will* have to do something about cylinder liners at one time or other, though.

If you replace with a Caterpillar-built liner, you're sure of a liner made of a special nickel-molybdenum-chrome alloy that's tougher and stronger than steel. more resistant to heat and abrasion. You're sure of controlled induction hardening that makes bare surfaces highly resistant to wear, and of bores chemically treated for easier break-in —better seating of rings. You're sure of precision machining for smoothness, roundness and straightness the full length of the liner.

If you replace with a non-genuine liner. can you be sure of anything?

Better get Caterpillar parts every time.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.



This is a genuine CAT cylinder liner. As many as 14 different inspections guarantee its composition, strength and hardness.*

CATERPILLAR*

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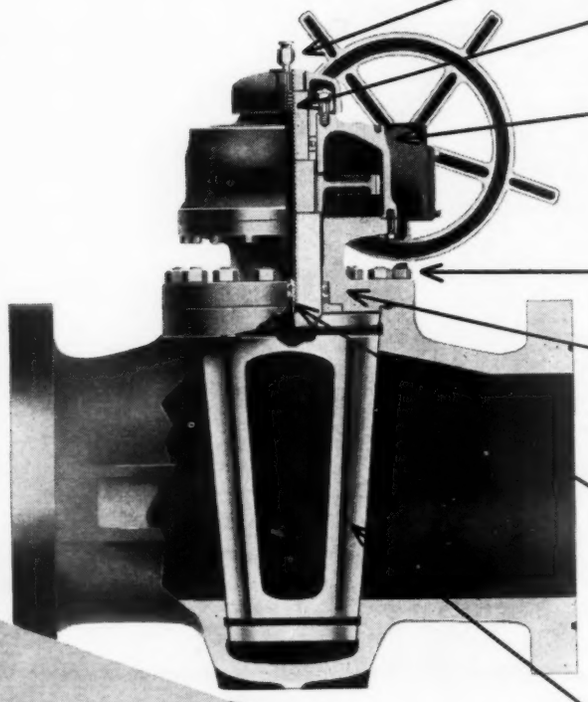
LET'S EXAMINE WALWORTH LUBRICATED PLUG VALVES



Button-head lubricant fitting and lubricant screw. Screw is not removed when using a Walworth High Pressure Lubricant Gun.

Lubricant-Fitting screw has "Telltale" safety groove.

For buried pipelines this yoke design permits simple attachment of handwheel and lubrication extensions without modifying the gearcase.

Standard bolt threads, rather than special threads, permit easy replacement from local stocks.

Two overlapping Teflon packing rings form an effective seal against leakage without "grabbing" the plug shank. Packing serves only as a seal and is not used to hold the plug in its seat.

In the stainless steel check valve unit, a transverse pin holds two balls in their seats. There is no chance for line pressure to get into the lubricant system when the valve is properly adjusted and lubricated.

Lubricant grooves completely frame the port openings and encircle the plug at the top and bottom, assuring a tight seal against leaks. Bottom circumferential groove is separate from, but connected with, the lubricant well.

ADVANTAGES OF PLUG VALVES

1. Quick Opening.
2. Positive seal on Light Hydrocarbons.
3. Less space than Gate Valves.
4. Available in Three-Way and Four-Way.
5. Can be used with Locking Device.

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Jones & Laughlin

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The Betz Sales Engineer, a *Very Important Person?*

We think so.

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It's his job to work shoulder to shoulder with you and your operating level personnel . . . assist in setting up correct systems of control . . . keep you fully abreast of the latest developments in Betz water conditioning technique . . . and a host of other services, from "trouble-shooting" to being a real part of your team.

Chances are, a Betz Sales Engineer can be the most important visitor you may receive today. Let him tell you how Betz *completely-integrated* water conditioning service can help you with your problem that's "different". You'll be glad you did.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: BETZ Laboratories Limited, Montreal 1.

BETZ

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

EXCLUSIVE

Average automobile horsepower has increased more in the past 5 years than in the preceding 20 years

Progress in HORSEPOWER

Charles L. McCuen

IF you are reading this during a normal working day, men are somewhere building automobiles. Other men are producing gasoline to run these automobiles. Before you finish this one short article, 600 completed automobiles will have come off the assembly lines. If these cars follow current averages, they will require 430,000 gal of fuel each year until they are scrapped some 15 years from now. In one ten-minute period, the automobile industry will have created an ultimate demand for more than 6,000,000 gal of fuel!

Both the petroleum and automotive industries are titans of the American industrial scene. We talk of 44 billion gallons of gasoline produced last year, of the 60,000,000 vehicles on the road today. And it is these tremendous quantities that magnify the importance of even small gains in making each succeeding year's new cars travel just a little bit farther on a given amount of gasoline. An over-all efficiency gain of just a few per cent can quickly add up to a saving of a billion dollars.

Another incentive for these national savings is the conservation of our natural resources. It is true that our known reserves continue to increase even faster than our consumption. Knowing the past achievements of our friends in the petroleum industry, I suspect this trend will continue for some time. But in spite of our best efforts in exploration and development, there still remains a finite amount of crude oil for this growing country of ours. I have the utmost confidence that long before our petroleum is exhausted we will have harnessed nuclear or solar energy for vehicular power; yet I feel that the conservation of our liquid fuel supply remains a strong incentive for continuing our notable progress in squeezing more and more mileage out of each barrel of crude.

Progress to Date

Satchel Paige, the indestructible pitcher, used to say, "Never look back — someone might be gaining on you!" But once in a while, an examination of where you've been may be helpful in correcting or maintaining your course. I think this is the case when we examine the progress made in automobile efficiency and performance over the past quarter century — progress that represents the joint contribution of both petroleum and automotive research groups.

Ton-miles per gallon is probably the best quantity to show the increase in engine efficiency gained through engine and fuel research. Fig. 1, based on data from our GM Proving Ground, includes 38 models from 18 manufacturers and shows the steady increase in ton-miles per gallon during the past 20 years. These data represent values obtained at constant speed on a level road.

Since few motorists operate their cars at constant speed on a level road and still fewer are used to thinking in terms of ton-miles per gallon, it is interesting to see what has been happening to tank mileage — the actual mileage obtained on the highway. Our data do not extend back beyond 1948 for this test, but, as shown in Fig. 2, there has been an improvement of better than 2 miles per gallon in the past 7 years. Unfortunately, the full measure of economy improvement obtained with controlled, reproducible engineering tests is not always apparent to the average motorist due to changes in traffic density (there are 60,000,000 vehicles on the road today compared to 31,000,000 in 1945), changes in highway driving speeds, and changes in individual driving habits.

This steady improvement in highway economy is particularly significant when we look at automobile performance, shown in Fig. 3. I say particularly significant because many people believe that the marked increases in performance provided over the past several years have meant a reduction in fuel economy. But the highway fuel economy curves of Fig. 2 show that these performance gains were obtained in addition to, and not at a loss of, improved fuel economy.

The Horsepower Story

Mention of car performance naturally leads to another subject, automobile horsepower. For years, we in the automobile industry have been striving to give our customers higher powered engines. If we made only modest progress in increasing horsepower, as shown in the 1930-1950 era of Fig. 4, it was only because we had not yet found the keys for unlocking greater quantities of power.

Early in the postwar period, a research project on the benefits of high compression showed that through proper design we could build high-compression, high-output engines suitable for passenger car use. These results were reported in a paper presented to the Society of Automotive Engineers. Two years later, the first of many totally redesigned engines was introduced, and our progress in increasing horsepower began to accelerate. The use of higher and higher compression ratios, coupled with the availability of constantly improved fuels, has resulted in stepping up both the power and economy of these improved engines. The use of larger, overhead valves, four-barrel carburetors, and larger manifolds has improved engine breathing and thus increased horsepower. Equally important has been the increased use of automatic transmissions, which has permitted the

XUM

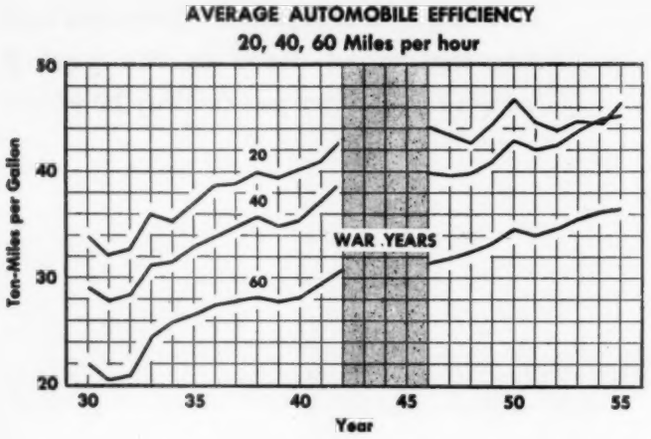
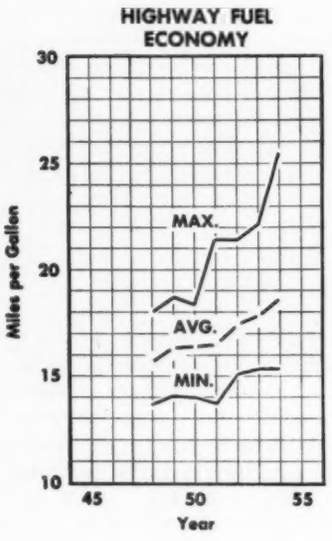


FIG .1.

FIG. 2.



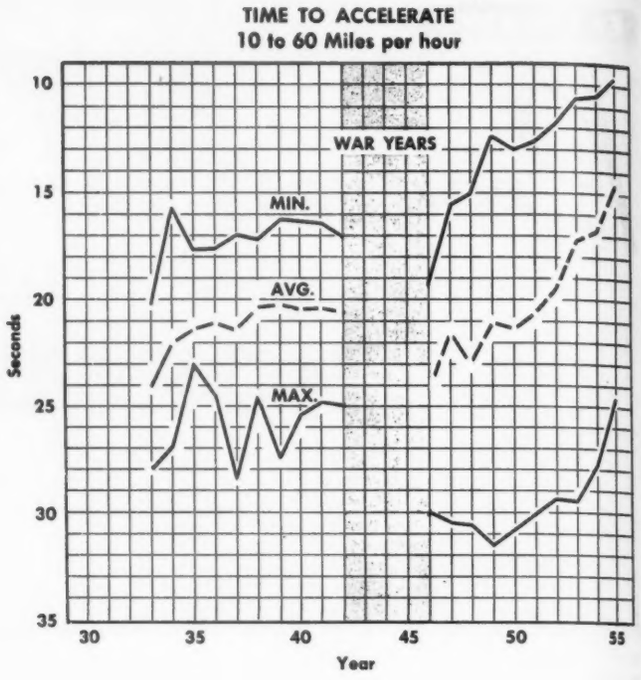


FIG. 3.

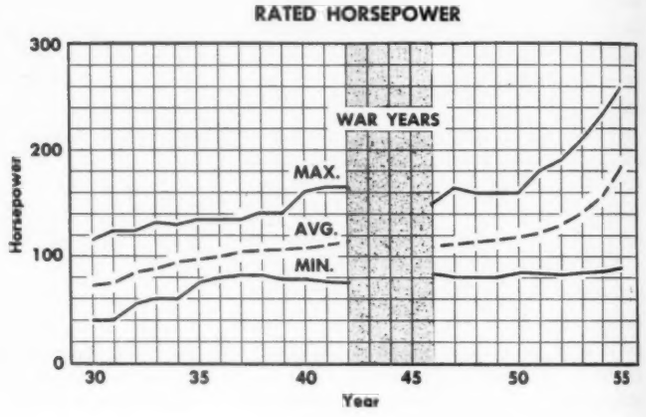


FIG. 4.

use of higher speed valve timing.

As a result of new knowledge in all of these phases of engine design, average automobile horsepower has increased more in the past 5 years than in the preceding 20. But few accolades greet this technical achievement; instead, we hear disparaging remarks about the "horsepower race," "overpowered or super-powered cars," etc.

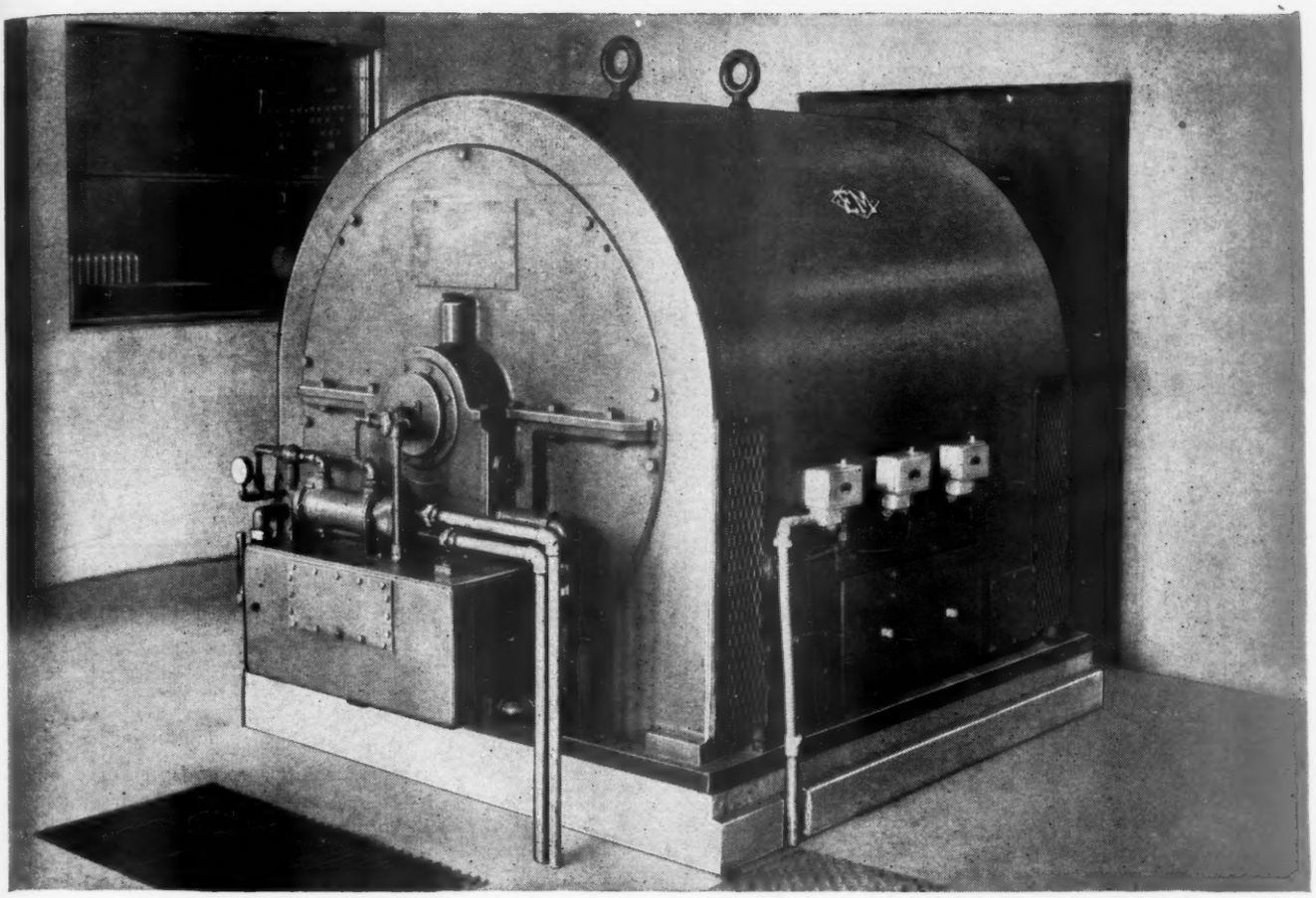
Why More Horsepower?

Many other people in the automotive industry have already pointed out that we build what the public wants to buy and that the cars which have made the greatest sales gains in the postwar period are those that have led the trend toward higher horsepower and higher performance. But there is so much unjustified fear of high horsepower that some of our more severe critics even suggest that the car-buying public should not be trusted to "vote" on this subject as it has in the past. These critics believe the manufacturers should stop producing such cars so as to take the choice out of their customers' hands. Yet it is quite unlikely that these same critics have any clear understanding of the fundamental engineering facts involved—facts that scientifically substantiate the average buyer's viewpoint that the higher horsepower cars simply are "nicer to drive."

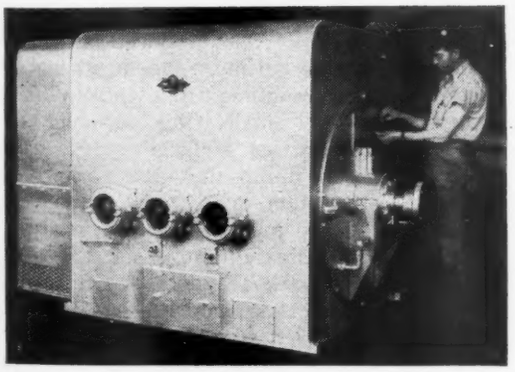
For example: You are on the highway on a holiday week end. A careful driver, you are following a car traveling 40 miles per hour. You, and the dozen or so drivers lined up behind you, are hoping for a break in the oncoming traffic so that you can pass. And finally the break seems to be there. You swing out to pass and press your accelerator to the floor. How long are you going to be facing that next approaching car? How long do you want to be facing him?

The last question is easy; you want to be exposed on the other lane of the road for the least possible time. How long you will be there depends, naturally, on the performance characteristics of your car. If you are driving the best performer of the 1955 models, it will require 497 feet and 6.3 seconds for you to gain approximately 3 car lengths (60 feet) on the car ahead and travel an additional 200 ft while pulling back into your own lane. If your car has performance equal to that of the average 1955 car, the figures are 563 ft and 7.5 seconds. For the average 1951 model, 607 ft and 8.3 seconds are required to do this same job. In just the past four years, we have reduced by ten per cent the time required for this common passing maneuver.

By adding one more factor to this comparison, we can see how performance improvements reduce traffic congestion. If we assume that the approaching car is traveling 60 mph, we find that for safe passing the mini-



This Pipe Line Pumping Station Requires Less Space and Less Operating Personnel



This is a 1000 hp, 3600 rpm E-M Weather-Protected Induction Motor. Four motors of this type, which require no building enclosure, have been built recently for pumping application on a large pipe line system.

● One man . . . a master control . . . and four compact high-speed E-M Squirrel-Cage Induction Motors! That's the new electric motor drive system for the pumps at a recently modernized pumping station of one of the nation's large pipe line companies.

This electric motor drive replaces a former installation of large engine equipment. Total station space has been reduced by 50% and far less operating personnel are needed. Specially designed for pumping station operation, the four E-M Motors are on one side of a firewall . . . centrifugal pumps on the other. One man in the master control room supervises the entire station pumping operation. Only motor attention necessary will be periodic bearing inspection.

E-M installations such as this enable you to invest *less* in capital equipment for pumping, to save appreciably on operating costs, and to reduce maintenance down-time to a minimum. E-M has designed these economical Induction Motors with extra-strong coil construction for full-voltage starting. They are cool-running, self-ventilated and have a self-contained pressure lubrication system.

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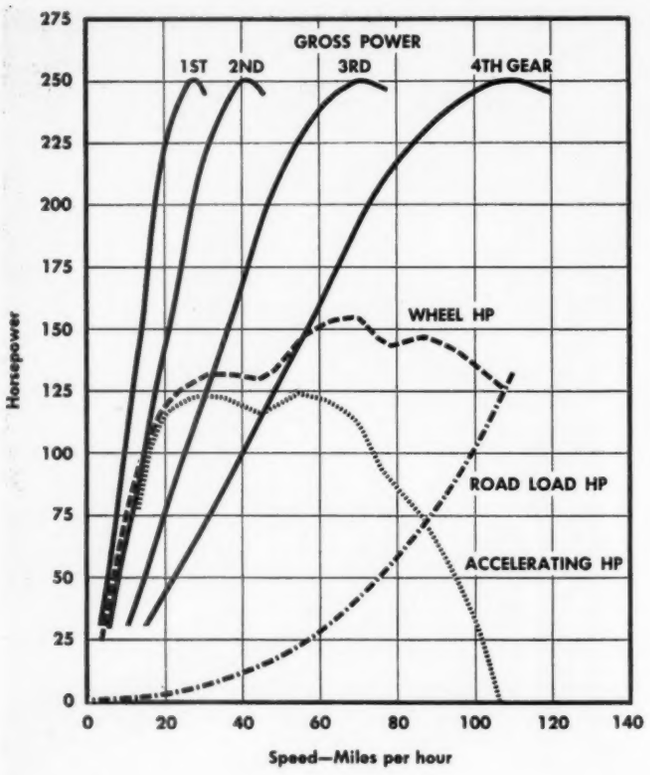


FIG. 5.

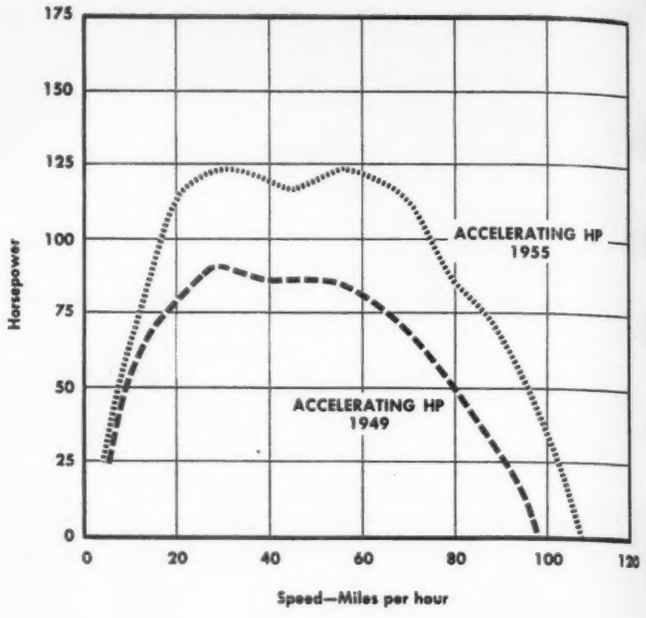


FIG. 6.

mum distance between you and the oncoming car must be 1337 ft if you are driving an average 1951 car, but that this is reduced to 1223 ft and 1051 ft, respectively, with the average and best 1955 models. Putting it another way, today's average car gives the driver more than 100 ft of extra clearance in this particular passing situation. Better performance does not mean that the driver can and will take more chances in passing; it simply means that he can safely and comfortably pass in considerably less distance, and hence has more opportunities for safe passing.

These illustrations are based on actual car performance data and serve to confirm statistically what most of us know from personal experience.

It is not merely coincidental that the high-performance cars are also the cars with high-horsepower engines. A further understanding of this horsepower-performance relationship is obtained if we look at a combined graphic presentation of some dynamometer and road test data. This form of presentation has been used by T. J. Carmichael and K. A. Stonex of the GM Proving Ground section and makes very clear why cars of over 200 hp have become commonplace. The data presented in Fig. 5 refer to a 1955 model employing a Hydra-Matic transmission.

The curves labeled Gross Power show the engine power developed in each gear range. These values are obtained with what is frequently known as a "bare" engine and are used in comparing engine designs as well as for establishing advertised horsepower. The exact test conditions for obtaining this gross power figure for General Motors engines have been published and widely distributed as a supplement to the General Motors Automotive Engine Test Code.

Although gross power data are widely used in engine development work, they don't tell you much about car performance. Here wheel horsepower is the important power item, and I'm sure few motorists appreciate that the power actually reaching the rear wheels is considerably less than the rated output of the engine. Much of this difference is due to the engine being installed in a car, for now the engine must drive a fan and generator, operate on an automatic rather than manually adjusted spark setting, operate with air cleaner, muffler, and tailpipe, and have its manifold heat valve operative, to mention a few of the more significant changes in operating conditions. Then too, the engine must supply power to make up for inherent gear, clutch and bearing losses in the drive train.

Another curve shown on our horsepower diagram is that for road-load horsepower. This charts the power required to propel the car at a constant speed on a level road. It follows that maximum speed is determined by the intersection of the road-load and wheel-horsepower curves.

The difference between the power available (wheel hp) and power required (road-load hp) is what is left for acceleration, and the curve labeled Accelerating Hp has been plotted by subtracting that for Road Load Hp from the Wheel Hp curve.

In Fig. 6, the accelerating-horsepower curve for the 1955 car is compared with that for its 1949 counterpart. And I think this comparison points up at least two significant facts. First, the 1955 car has a definite advantage in accelerating horsepower. Since car weight, gear ratio, and frontal area have not changed appreciably, this improvement in accelerating horsepower has produced a definite performance improvement, giving the car owner more of that "nice to drive" feel. Incidentally, this particular car has increased highway economy 19 per cent during this same period.

The other major point emphasized by the comparison is the relatively small increase in top speed for the 1955 model. This in spite of the fact that the 1955 model is rated nearly 100 hp higher than the 1949 car.

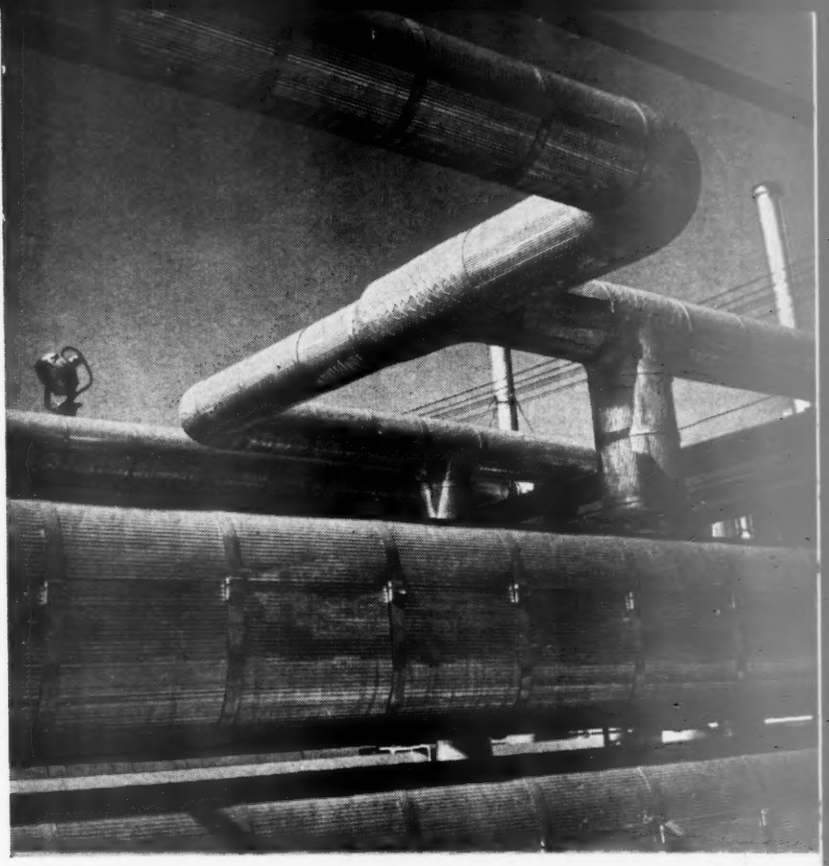
A look at the shape of the road-load curve reveals how we can materially increase cruising-range performance without appreciably changing top speed. Nature has seen fit to make road-load horsepower, composed of wind and rolling resistance, a function of the cube of the velocity. Hence, at the high-speed end of the curve, relatively large increases in power produce only small increases in speed.

Is High Horsepower a Killer?

High horsepower has been unjustly stigmatized in at least one other respect — that of highway safety. Pessimists who fear and even shout that

How Olin Mathieson Uses Childers Jacketing For Insulated Lines

Jacketing problems at new plant ranged from covering tall towers to irregularly-shaped heat exchangers. Read how aluminum jacketing solved these problems.



More than 244,000 square feet of Childers .006″ Jacketing and 35,000 square feet of heavy weight Childers Jacketing was used in this new Olin Mathieson plant to weather-proof insulated lines, towers and vessels. Close-up above shows how aluminum jacketing was applied with strapping and seals.

Low first-cost, long life, and easy installation were the big reasons Olin Mathieson Chemical Corporation used Childers Aluminum Jacketing for outdoor insulated lines in their new Brandenburg, Ky., petrochemical plant.

Mathieson used Childers standard weight jacketing on their insulated lines. Heavier weights of Childers Jacketing were used on high towers and vessels where a stiffer material was needed to support the vertical weight of the jacketing.

Engineers report that Childers Jacketing is inexpensive to apply. It comes in easy-to-handle rolls 4 ft. wide and 100 ft. long. Just shears and a pocketknife are the only tools needed to apply. And because the jacketing is aluminum it needs no painting . . . stays clean and new looking even after years of service.

Childers Jacketing is easily removable, too. Just remove the strapping and jacketing can be taken off for inspection of the lines. Then same jacketing can easily be put back on the insulated line.

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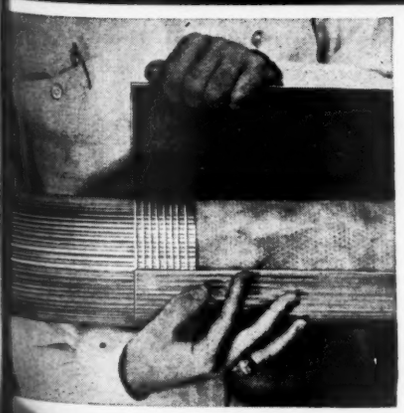
Try this low-cost protection in your plant. Write today for engineering data and information. You can order a 400 sq. ft. roll to test on one of your insulated lines. No obligation. Address: Childers Manufacturing Company, Department PE-11, 3620 West 11th St., Houston, Texas.

Only Childers Jacketing Offers LAP-SEAL

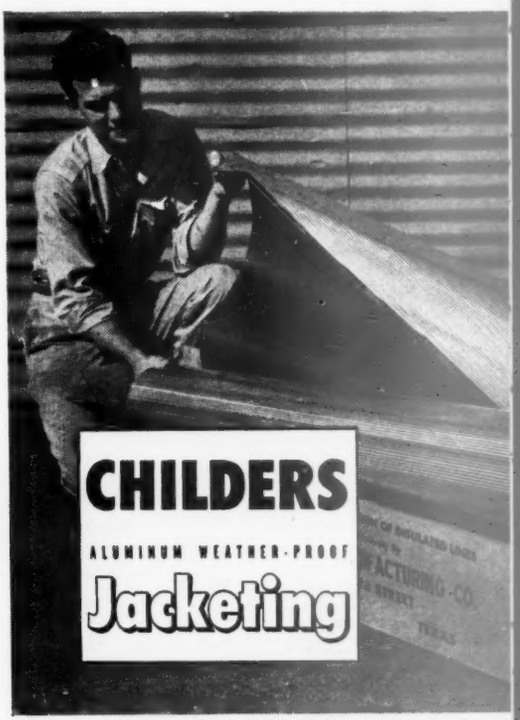


LAP-SEAL **is a series of eight ribs rolled into the underlapping edge of the jacketing.**

LAP-SEAL **makes more positive weather seal.**

LAP-SEAL **saves labor—2″ ribbed edge eliminates measuring for circumferential lap.**

LAP-SEAL **(patent applied for) is an exclusive "plus" available on all Childers Jacketing at no extra cost.**



Each roll of Childers Jacketing comes individually packed like this in a heavy corrugated carton. Rolls are 4 ft. wide. With moisture barrier attached they are 100 ft. long; without moisture barrier they are 200 ft. long. They are well protected for field storage if kept dry. Individual boxes are light enough for one man to handle. (Adv.)

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The Author

Charles L. McCuen is vice president of General Motors and general manager of

General Motors Research Laboratories division. A native of Stockton, California, he was graduated from the Polytechnic College of Engineering at Oakland, California. McCuen entered the automotive business as a vice president of the Cole California Motor Company immediately after graduation. In 1926, he entered the GM organization as an engineer for the Olds Motor Works at Lansing, Michigan. He became general manager of GM Research Laboratories division in 1947. He initiated experiments with GM's first gas turbine vehicles, the XP-21 Firebird and the GM Turbocruiser.

better performing, somewhat speedier automobiles mean more highway fatalities have had no backing from the National Safety Council traffic statistics. In 1954, for example, traffic deaths dropped some 6 per cent from the previous year; from 38,300 to 36,000. Automobile death rates per vehicle-mile have been in a steady decline since 1925, reaching an all-time low of 6.4 per 100,000,000 vehicle-miles in 1954. This 6.4 is less than half the 1937 death rate, yet average horsepower in 1954 was 152 per cent of the 1937 average.

Of course, this decline in death rate reflects the efforts of many safety, education, and engineering groups, and the inverse relationship between death rate and horsepower does not in itself "prove" anything. Still, many motorists are alive today only because their cars had sufficient agility to compensate for an error in their own or some other driver's judgment.

Summary

The current emphasis on improved performance through higher horsepower is but one phase of the automobile development picture. Throughout the past half century, automotive engineers have placed varying emphasis on a number of problems, some of which are never completely solved. At first, attention was focused on durability. When cars became reasonably trouble-free, the engineers sought to make them go faster. Soon the roads, rather than the cars, limited driving speed, and development work was concentrated on economy. But a review of past history shows that few, if any, of the hard-won gains in one area have been sacrificed to further another. The result has been a continually improved car, in all respects. I look for these same trends to continue. * * *

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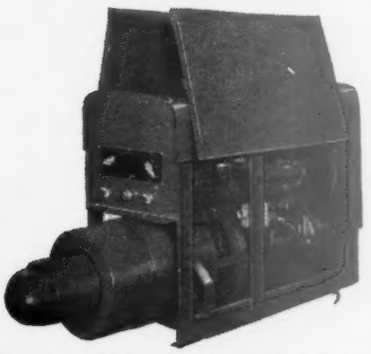

Figure 1. 200 amp "Shield-Arc" *Gasoline Engine Driven with Lincoln Dual Control. Current range 40 to 250 amperes.*

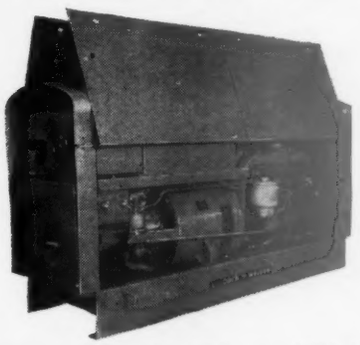

Figure 2. 300-400-600 amp "Shield-Arc" *with Lincoln Dual Continuous Control. Gasoline Engine Driven. Current ranges 60-375 amps, 80-500 amps, 120-750 amps.*

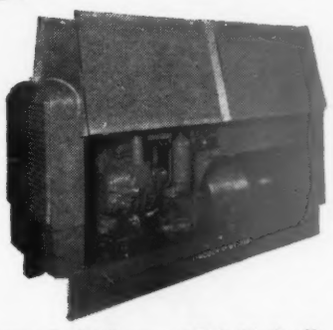

Figure 3. 300 amp "Shield-Arc" *with Lincoln Dual Continuous Control. Diesel Engine Driven. Current range 60-375 amps.*

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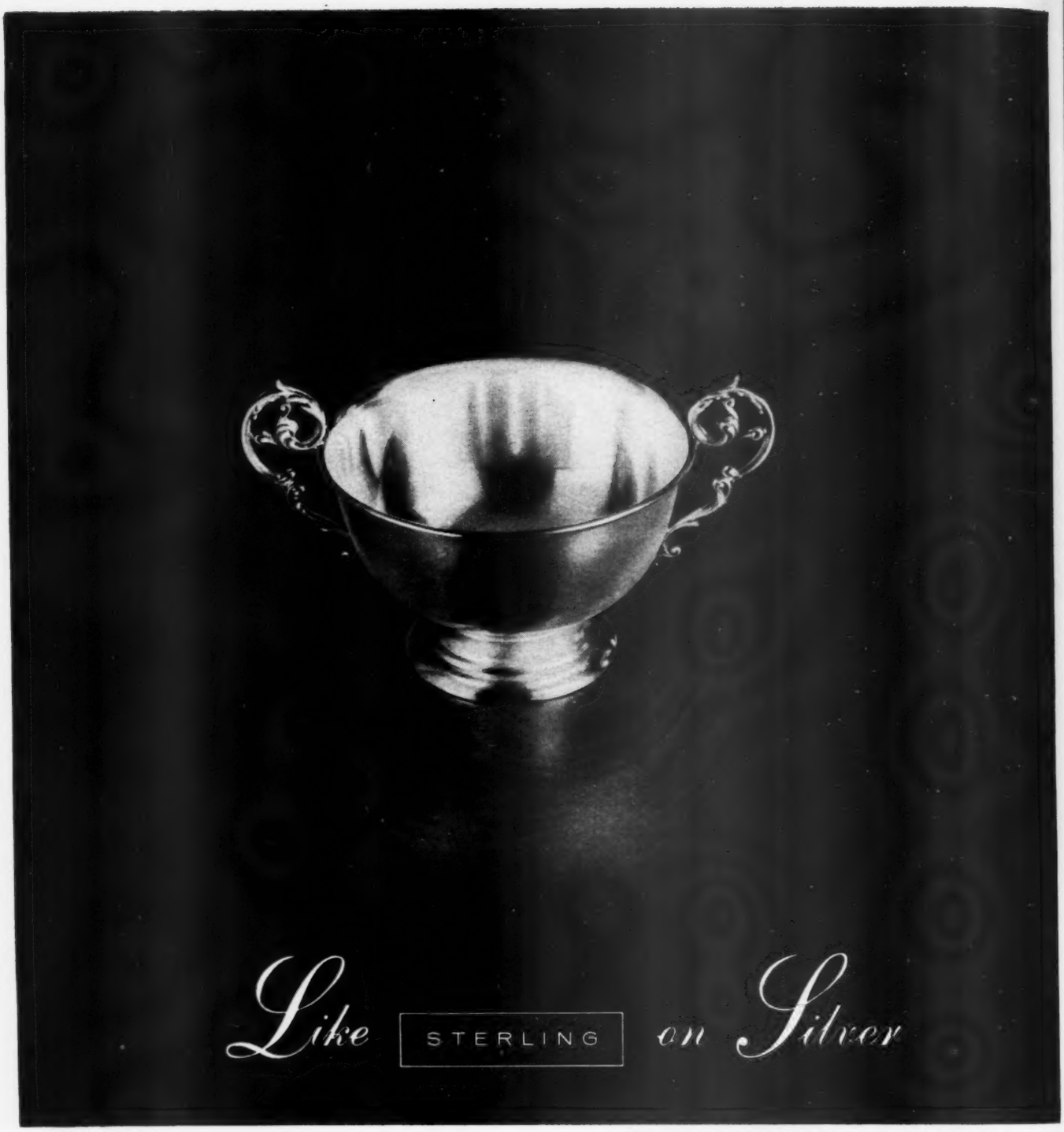

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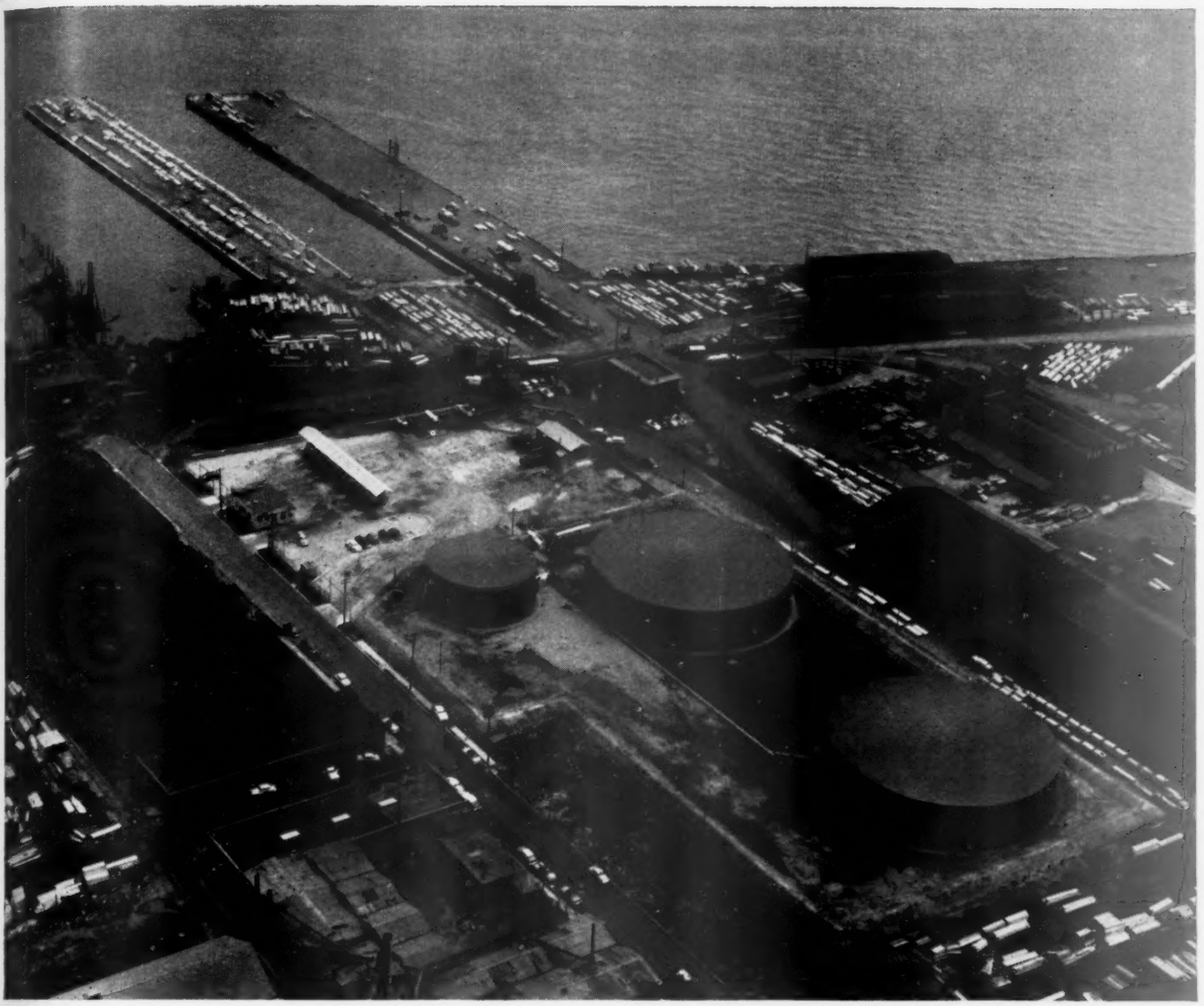

Two Independent Marketers Build 240,000-bbl Terminal in Philadelphia

The big Bethlehem-built tanks you see here are located at Philadelphia's newest deep-water terminal. The operating firm, Ontario Terminals, Inc., is a joint venture of two long-established independent marketers, Allied Oil Company and Major Petroleum Company.

Each of the two larger tanks, measuring 150-ft in diameter by 32-ft high, provides over 100,000 bbl of storage capacity for No. 2 fuel oil. The 80-ft by 32-ft tank is used to store approximately 28,000 bbl of kerosene. These products are distributed through the several bulk stations operated individually by Allied and Major in the metropolitan Philadelphia area.

Other facilities on the five-acre tract include tanker and barge berths, an up-to-the-minute truck loading rack and an attractive office building. Architect for the project was Sidney Jelinek; engineer and constructor was Leonard Shaffer Co.

The tanks shown here are typical of the API-specification, cone-roof units built by Bethlehem. Other types of tanks designed, fabricated and erected by Bethlehem include a wide variety of floating-roof and lifter-roof tanks. Their design and construction features are described in our Booklet 298. If you would like to receive a copy, please write to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

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"Barrel Number One" Makes OPW Debut

"Barrel Number One," the American Petroleum Institute's new motion picture, will make its public debut on Sunday, October 9—the first day of the oil industry's annual Oil Progress Week.

Step by step, the picture shows how "Barrel Number One" is found, and then follows that barrel through pipe lines and tankers to refineries and finally through market places to the consumer.

The story is narrated by the various people who work in oil—the geologists and explorers, the drillers and producers, transporters, marketers, and researchers. Emphasis is placed on the many talents, trades, and types of people needed to keep the nation supplied with petroleum products.

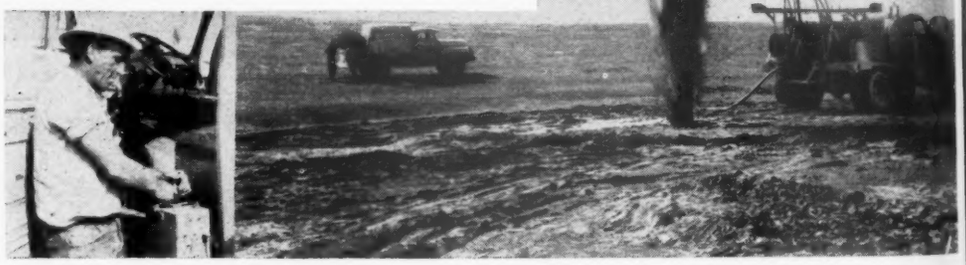
"Barrel Number One" was filmed on location in various sections of the country. Beautifully executed, it contains many unusual scenes of oil installations and developments. It is a black and white production, and runs 29 minutes.

Like other API motion pictures, "Barrel Number One" has been designed for industrial and public use. It is suitable for general audiences of all age groups, and is expected to be particularly valuable for schools and other educational institutions, and for oil companies in their training programs.

"Barrel Number One" is the 1955 sequel to other API productions such as "The Story of Colonel Drake" and "American Frontier." Several API motion pictures have won national and international awards for excellence.

"Barrel Number One" was planned and supervised for API by Film Counselors, Inc., New York.

Drilling the well, after the spot is chosen, can cost from $50,000 to more than $1,000,000.



Seismographic groups "sound" the earth by setting off dynamite explosions, and recording shock waves in the endless search for oil.

Dispatching stations can "side-track" shipments to allow rush orders to move ahead. The station can move different products through pipe lines without appreciable mixing of liquids.

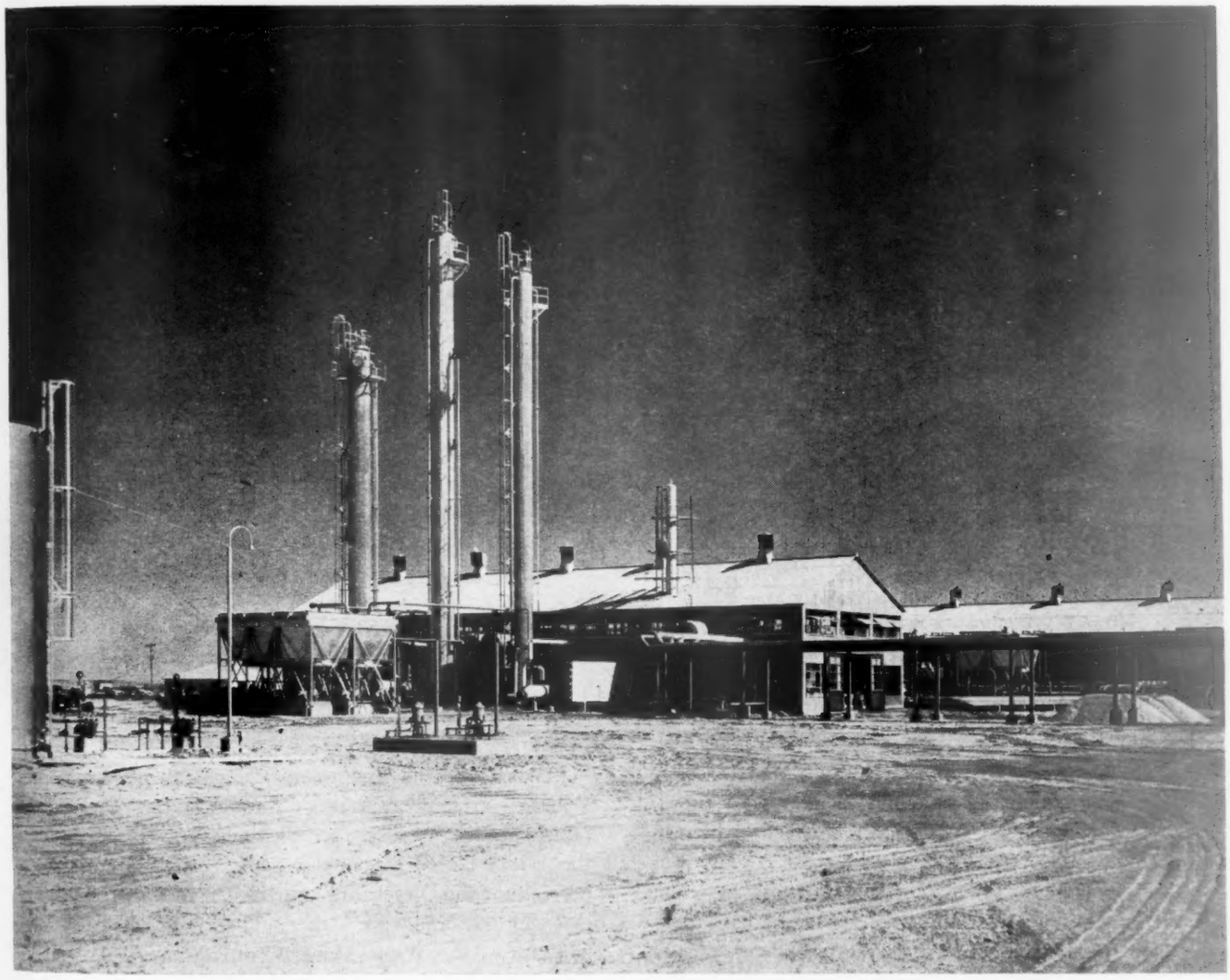
Research plays a continuous role in oil operation, with more than 15,000 persons engaged in laboratory work or scientific study.

How to run a gasoline plant without WATER

The new Adena plant near Fort Morgan, Colorado is now producing gasoline despite the total absence of a source of water for plant use. Water for drinking and sanitary purposes must be brought in by truck.

Flexibility is a key feature of this new plant which is operated for a combination of companies by the Pure Oil Company. Coupled with four stages of gas compression are two stages of refrigeration to meet maximum summer requirements. During the winter it is possible to divert compressor capacity from refrigeration to additional gas processing. Initially it is handling 10,000,000 cubic feet per day of gas. Ultimately it may go as high as 20,000,000 cubic feet per day.

The plant is designed for winter conditions similar to those experienced at other cold country plants designed and built by Stearns-Roger.



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PERSONALS

Edward H. McCollough, Tulsa, Oklahoma, has been named president of Amerada Petroleum Company succeeding **Alfred Jacobsen,** New York City, who will become chairman of the board. McCollough had been executive vice president before his promotion. Jacobsen, who had served as president since 1929, will continue as chief executive officer. Also selected for a new post is **B. B. Weatherby,** Tulsa, now senior vice president.

Joseph L. Seger, executive vice president of Carter Oil Company, Tulsa, Oklahoma, has been elected to the board of directors of Esso Research and Engineering Company. Seger was formerly president of Interstate Oil Pipe Line Company, Shreveport, Louisiana. Esso Research also announced selection of **Stanley C. Hope,** president of Esso Standard Oil Company, and **Cecil L. Burrill,** chief economist of Standard Oil Company (New Jersey), to the executive committee. They are also on the Esso Research board. All companies are Jersey Standard affiliates.

Robert W. (Bob) Griffith has been named general manager of the gas-gasoline division, production department, Sunray Mid-Continent Oil Company. Griffith until recently was assistant manager of Sunray's refining department. In the new alignment of the department, **E. J. (Ernie) Mills** will continue as manager of Sunray Mid-Continent's field plant operations. **C. F. (Boots) McCarroll** will be manager of the gas sales division, and **Carl A. Lemon** will be manager of LPG product distribution and sales from field plants. Griffith joined the company in 1948, having been successively assistant superintendent of gas-gasoline operations, manager of the gas-gasoline division, and assistant manager of manufacturing and pipe lines, prior to his present appointment. Mills became associated with the company in 1943 and has served as project superintendent, West Texas district gas superintendent, and manager of the gas-gasoline division at Tulsa, Oklahoma, in 1952. McCarroll began work with Sunray in 1945 as an engineer with the company's production department in South Texas. He was transferred to the Tulsa general office in 1948 and was named production department office manager in 1950. Since 1950, he has been engaged in special assignment work in the company's production and exploration departments, having been named manager of the gas sales division in 1953. Lemon came to the company in 1926, working first as assistant traffic manager and assistant sales manager in the gas-gasoline division. He was named manager of LPG plant sales and distribution in May of this year. **Loren Buck,** who joined Sunray Mid-Continent in June, has been named chief engineer for the gas-gasoline division of the company's production department. He formerly was associated with Stanolind Oil and Gas Company as chief project engineer.

Robert E. Mays, assistant manager of the comptroller's department, has been appointed manager of the new budget department of Creole Petroleum Corporation, while **H. Donald Schersten** will replace him in his previous position. **Jack F. Holmes** will, in turn, replace Schersten as procedures, statistics, and auditing coordinator. **William S. Glendening,** head of the Caracas petroleum engineering section will become assistant manager of the Western division in Maracaibo, Venezuela. In 1938, Mays became a certified public accountant in the state of Texas. He had previously worked two years for Standard Oil Company of California and its subsidiaries. In 1949, Mays joined Creole as an accountant. In April of this year, Mays was designated temporary assistant manager of the Western division. He will leave this post to assume his new position. Schersten, who was graduated from the University of Temple in Philadelphia, Pennsylvania, has had more than a decade's experience in the oil industry. Glendening, a graduate of the University of Kansas, went to Venezuela in 1938 as a petroleum engineer for the Lago Petroleum Corporation in La Salina. In 1952, Glendening was designated head petroleum engineer for Creole throughout all Venezuela, which post he held until his recent appointment.

Alden Donnelley of Midland, Texas, vice president of Honolulu Oil Corporation, has been elected chairman of the southwest district of the American Petroleum Institute's division of production. The division was recently split into a southern and a southwestern district. **M. R. Hayes,** also of Midland, Phillips Petroleum Company production superintendent, will serve as advisory committee chairman in the southwest district. **E. L. Cook,** Dallas, Texas, Magnolia Petroleum Company, will be southwest district committee chairman on drilling fluids. Southern district chairman will be **T. J. Fuson,** Houston, Texas, Humble Oil & Refining Company. Head of the advisory committee in that district will be **S. C. Oliphant,** also of Houston, Tennessee Gas Transmission Company. **Robert E. Harris** has been appointed a district representative in the Minnesota-Dakotas district of the Oil Industry Information Committee of API. Harris is succeeding **John Richardson,** who has been promoted to the Kentucky-Ohio-Tennessee district office. He is a graduate of the University of Minnesota. He came to the OIIC from Brede, Inc., an advertising firm in Minneapolis, Minnesota. His past experience includes service with the Minneapolis Star & Tribune, United Press, and International News Service. He will work out of the Minneapolis OIIC office.

Forrest N. Baughman has been elected secretary of Envoy Petroleum Company. Baughman, former head of the firm's accounting department, succeeds **John Lelicoff,** who has resigned to form a business of his own.

William A. Claussen, San Francisco, California, American Petroleum Institute, and **Lawrence M. Richards,** Richfield Oil Corporation, will represent the petroleum industry on the newly formed technical advisory committee of the Air Pollution Foundation. Claussen is executive secretary of the API smoke and fumes committee. Richards is assistant manager of research and development for Richfield and formerly was director of air pollution research for Stanford Research Institute.

Donald G. Clark has been appointed vice president of Allied Oil Company. Allied Oil, a supplier of industrial fuel oils in the Upper Mississippi-Ohio River and Great Lakes area, is a division of Ashland Oil & Refining Company.

John H. Jennings, manager of the petroleum department of the Colorado National Bank, has been appointed a vice president of the Denver bank. Jennings went to Denver as manager of the petroleum department when it was first established in 1954. Formerly he had been chief evaluation engineer for the Deep Rock Oil Company, and also had been employed by the Sunray Oil Corporation, Mountain Fuel Supply Company, and Ohio Oil Company. A graduate of the University of Pittsburgh, Jennings is a licensed engineer.

Charles E. Simons, executive vice president, Texas Mid-Continent Oil & Gas Association, has been named on the advisory committee of the Texas State Board of Education to study utilization of school buildings.

S. Douglas Turner, of Calgary, Alberta, Canada has been appointed to the position of manager, Alberta division, of the Canadian Petroleum Association. Turner, born and educated in Toronto, attended the engineering school, University of Toronto, and upon graduation was employed by Canadian Westinghouse Company, Ltd., in Hamilton, Ontario. Following World War II he attended Osgoode Hall Law School in Toronto, being graduated in 1949. Turner succeeds **John W. Proctor,** recently appointed general manager of the association. Turner is a member of the Law Society of Alberta, the Calgary Bar Association, the Law Society of Upper Canada, the Association of Professional Engineers of the Province of Ontario.

W. E. V. Abraham has resigned from the board of the British Petroleum Company, Ltd., and **William Ewing Eadie** has been appointed to fill the resulting vacancy.

Frank B. Fulenwider has been named as an assistant sales manager of the central division of Tide Water Associated Oil Company.

Charles E. Webber has been appointed technical adviser to John G. Pew, Sun Oil Company vice president in charge of production. **William Abnett** has been named assistant technical adviser. He formerly was special assistant to the late **James E. Pew,** manager of Sun's natural gas division. Webber, a graduate of Louisiana State University, was assistant director of the Petroleum Administration for War's natural gas and natural gasoline division in 1945, when he was named assistant manager of Sun's natural gas division. Abnett, a graduate of the University of Wisconsin, began his Sun Oil career in 1949, as special assistant to the late James E. Pew. Before joining Sun Oil, Abnett was employed by The Carnation Company, Oconomowoc, Wisconsin, as a mechanical engineer.

George J. O'Brien, vice president, Los Angeles, California, area, Standard Oil Company of California, observed his thirty-fifth anniversary with the company recently.

J. R. Owen, division sales manager of The Carter Oil Company, Denver, Colorado, has been named chairman, executive committee, Colorado Petroleum Industries Committee. He has served as vice chairman for three years.

Robert D. Townsend, assistant to the executive vice president of General Petroleum Corporation, has retired after 27 years service with the company.

Personals

Jack W. Roach, presently vice president of Deep Rock Oil Company, Tulsa, Oklahoma, has also been named assistant to the president, **F. C. Love.** He will continue to maintain his office in the Kerr-McGee building at Oklahoma City. In his new capacity, Roach will co-ordinate activities of Deep Rock's research and development department, and, in addition, will be in charge of special projects assigned from the president's office. Among the first of these projects will be a study to determine the steps to be taken to further increase the octane of gasoline manufactured at the company's refineries. **Robert M. Chesney,** vice president, who is in charge of the company's Cushing, Oklahoma, refinery, has also been placed in charge of Deep Rock's Wynnewood, Oklahoma, plant. He is moving his office from Cushing to the Kerr-McGee building in Oklahoma City, where he will co-ordinate the operations of both refineries.

Harold L. Curtis has been appointed to the newly created post of vice president in charge of public relations for Shell Oil Company. Curtis had been assistant to the president with responsibility for public relations since 1947. A native Californian, he joined Shell in 1923 as a service station attendant.

Donald F. Steinke has been appointed assistant training coordinator at Standard-Vacuum's producing and refining subsidiary, Standard-Vacuum Petroleum Maatschappij, in Indonesia. He was formerly director of power education at Dow Chemical, Midland, Michigan.

H. C. Walker, The Ohio Oil Company's personnel supervisor at Casper, Wyoming, has been appointed assistant manager of the personnel department succeeding **J. R. Hause,** recently deceased. Walker will be located in the general office at Findlay, Ohio. **R. E. Engdahl,** assistant department head of the Casper personnel department, will take Walker's place as personnel supervisor. Walker has served in his present position in Casper for the past six years. Engdahl became personnel man at Casper in 1952 and advanced to assistant department head last June. He began his varied experience with Ohio Oil as a draftsman at Cody, Wyoming in 1926. In 1944 he became oil scout in the Casper land department.

James R. Arrington has been named manager of the economics department of The Carter Oil Company, succeeding **G. D. Priestman.** He will be head of the economics section of the producing co-ordination department. Arrington went to work for Carter as a roustabout at Otis, Kansas, in 1937 following his graduation from the University of Tulsa with a BS degree in chemical engineering. Priestman was graduated from the University of Virginia in 1937 with a BS degree in chemical engineering.

Marion W. Boyer, a member of the board of directors of Standard Oil Company (New Jersey), has been elected to the board of directors of the Commerce and Industry Association of New York, Inc. Boyer has been with the Jersey Standard organization since 1927, when he left the Research Laboratory of Applied Chemistry at the Massachusetts Institute of Technology to begin work as a chemical engineer in the Esso Laboratories at Baton Rouge, Louisiana. In 1935, Mr. Boyer was elected a director of Standard Oil Company of Louisiana, now Esso Standard Oil Company, was elected vice president the following year, and became head of all Esso's Baton Rouge operations in 1945. Transferred to New York in 1949, he assumed responsibility for all manufacturing operations of the company. He was executive vice president of Esso Standard prior to his election to the board of Jersey Standard. A native of Muncie, Indiana, Boyer is a graduate of and received his master's degree in chemical engineering from Massachusetts Institute of Technology.

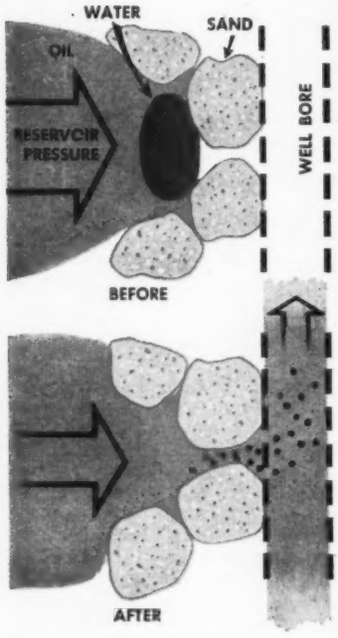
Socony Mobil Oil Company, Inc., has elected a new board chairman, a new president, and two new directors. **B. Brewster Jennings,** president since 1944, was made chairman of the board of directors of the company to succeed **George V. Holton,** who has retired. **Albert L. Nickerson,** vice president and director in charge of foreign trade, was chosen president, succeeding Jennings. **Austin T. Foster** and **Paul V. Keyser Jr.,** were elected directors.

At the time of Foster's election to the board of directors, **W. Lawrence King** and **Herman J. Schmidt** were appointed associate general counsel.

Keyser, a BS and MS graduate of the Massachusetts Institute of Technology, has been with the company since 1930.

Holton, the retiring chairman of the board, has concluded 34 years with Socony Mobil. In 1932 he became general counsel. He was elected a director the same year, a member of the executive committee in 1933, a vice president in 1938, and chairman of the board in 1948.

Improve Oil Production with PR-277



PR-277 removes water blocks by lowering the oil-water interfacial tension which causes the water droplets to lose their rigidity and allows the oil to flow.

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Recently, seven poor producing wells were treated with PR-277. Only 196 gallons of this chemical were used, resulting in a total *daily* oil production increase of 165 barrels.

The added daily production paid for the total chemical cost in slightly over two days' production at the increased production rate.

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Pumping Progress Report

FOR HYDRAULIC ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

SPACE, in many pump installations, is a major problem. Another is the necessity for special foundations. When new installations are considered, these factors may dictate more elaborate construction than should be necessary. And for replacement or modifications of existing systems, they may require expensive piping and equipment changes.

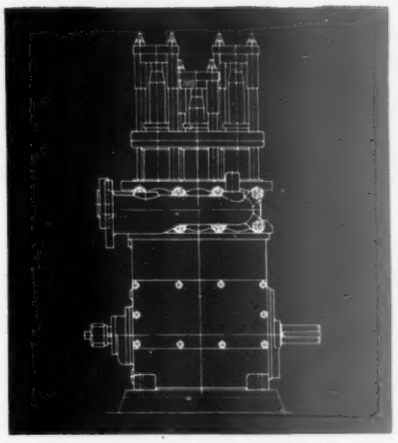
COMPACTNESS OF DESIGN, while often desirable, is not necessarily the answer. Simplicity of design — as in the case of ALDRICH Direct Flow Pumps — may be a better solution.

SIMPLICITY OF DESIGN brought about the first inverted Triplex and Quintuplex Pumps and ultimately Septuplex and Nonuplex Pumps. This Aldrich design innovation brought to pump users many economies of space, maintenance and operation they had never known.

INVERTED PUMP DESIGN permits the use of less expensive foundations. With the crankshaft located near the floor there is no need for expensive foundation work to raise the driver or lower the pump. Then, too, inverted pumps require fewer square feet of floor space than conventional pumps.

MAINTENANCE COSTS ARE REDUCED. Fluid-end, where most work is done, is at chest level. Bearing replacements are made without removing heavy crankshafts or connecting rods. Crossheads on all Direct Flow Pumps can be worked on or removed from pump without disturbing fluid-end.

TELL US ABOUT YOUR PUMPING PROBLEM. The chances are that one of our standard pumps — or a modification of one — will do your job. Detail your problem and we'll send you a copy of the Data Sheet that describes the Direct Flow Pump we recommend. Write to: The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.



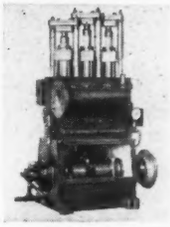
Aldrich inverted vertical pump design

...for your tough pumping problems specify ALDRICH

The entire line of Aldrich Direct Flow Pumps feature two outstanding design innovations—inverted vertical design and sectionalized fluid-ends. These two features have helped make Aldrich the organization hydraulic engineers turn to when they face tough pumping problems. If you have a pumping problem, turn it over to the men who have never turned down a challenge.

CHECK THESE ADVANTAGES OF INVERTED PUMP DESIGN:

Smaller Foundations
Simpler connection with prime mover
Less floor space required
Reduced maintenance costs



Write today for Data Sheets describing the Direct Flow Pump Series.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
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...You can't beat these drop-head dies for easy work, perfect threads... and long trouble-free service!

Every RIDGID Pipe Tool TESTED before shipment

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Drop-Head Dies

for ⅛" to 2" pipe

Each size die head snaps instantly into ratchet handle. Dies reverse quickly for close-to-wall threads, easily removed for regrinding. Left hand dies available.

00R, ⅛" to 1"
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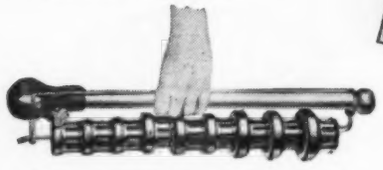
Buy them from your Supply House.

Every RIDGID Pipe Tool individually TESTED before shipment.



Carrier free with complete sets.

RIDGID Work-Saver Pipe Tools

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DEATHS

Barton A. Myers, petroleum consultant and a former vice president of both Standard Oil Company (New Jersey) and International Petroleum Company, Ltd., of Toronto, Ontario, Canada, died recently at Tulsa, Oklahoma. When he retired in 1943, Myers was vice president in charge of production and also vice president of International Petroleum, a Standard subsidiary.

Richard L. Jones Sr., vice president in charge of sales for the Tennessee Gas Transmission Company, died recently at his home in Houston, Texas, following a brief illness. A native of Macon, Georgia, Jones had been a resident of Houston for about 19 years. He joined the Tennessee Gas Transmission Company as gas sales representative in 1949. A year and a half later, he was named sales manager and was elected vice president in 1954.

O. D. Robinson, board chairman of Republic Oil Refining Company and a trustee of the National Petroleum Association, died recently at his home in Coraopolis, Pennsylvania, after a long illness.

Robinson was also president of the Republic Pipe Line Company and of the Duval Pipe Line Company, a vice president of Melben Oil Company, and a director of Hiawatha Oil and Gas Company and of Penn-Ohio Gas Company.

Carl E. Duffield, Tyler, Texas, oilman and dog and horse fancier, died recently of a heart attack after collapsing at Midway Airport in Chicago, Illinois. He was president of Lester & Duffield, Inc., with oil offices at Dallas and Abilene, Texas.

Hugh S. Chancey, owner of the Portable Drilling Corporation, died in a hospital at Tulsa, Oklahoma, recently after a brief illness. He founded Portable Drilling in 1936 and was also vice president and treasurer of the Gackle Drilling Company, Inc. Chancey was a pioneer in the unitized rotary drilling process for oil wells.

Robert J. Crawford, manager of the refinery accounting department of Sun Oil Company, died recently while on vacation at Eagles Mere, Pennsylvania. He joined Sun in 1933 as an auditor and later handled special assignments for the company's production and marketing departments.

Raleigh W. Baker, an employee of Humble Oil & Refining Company since 1925, died recently at his home in Baytown, Texas. He was the father of State Representative Robert W. Baker.

Herbert J. French, vice president of The International Nickel Company, Inc., and assistant vice president of The International Nickel Company of Canada, Ltd., died recently in Rochester, Minnesota, after an extended illness. French was the recipient of many distinguished technical awards for his contributions to the science of metallurgy.

Cecil L. Hightower, personnel and safety director for the United Gas System at Shreveport, Louisiana, died at his home there recently after a short illness. He had been with United Gas at Shreveport since the early 1930's and had held a similar position with the Dallas Power & Light Company at Dallas, Texas, in the 1920's.

LAUGH with BARNEY

A man is that irrational creature who is always looking for home atmosphere in a hotel and hotel service around the house.

"FOUND—Lady's purse, left in my car while parked. Owner can have same by paying for this advertisement. If she will explain to my wife how the purse got there, I will pay for the ad myself."

"Am dere anybody in the congregation what wishes prayer for deir failin's?" asked the colored minister?

"Yassuh," responded Brother Jones. "Ah's a spendthrif', an Ah throws mah money round reckless like."

"Ve'l well. We will join in prayer fo' Brother Jones—jes' afteh de collection plate have been passed."

Frank: I don't see how you tell those Smith twins apart.

Hank: That's easy. Mabel always blushes when we meet.

There are two well-known finishes for automobiles: Lacquer and liquor.

A Wall Street statistician undertook a modified Kinsey investigation of his own. According to him, man's relationship with the opposite sex can be divided roughly into seven stages:

1. Wha-a-a! I want my mama!
2. G'wan, beat it. We don't want any old girl playing with us!
3. Gee, Alice, you're beautiful!
4. If you don't marry me, I'll shoot myself!
5. All right, go home to your mother. See if I give a darn.
6. She's considerably younger than I am, Alice, I admit, but she understands me!
7. Kitchy-koo! Did you hear that, Alice? Listen, she said "Grandpa!"

"I want some grapes for my sick husband. Do you know if any poison has been sprayed on them?"

"No, ma'am. You'll have to get that at the druggist's."

Mechanic: With a car like that, my advice is to keep it moving.

Car Owner: Why?

Mechanic: If you ever stop the cops will think it's an accident.

"Doc," said the old timer as he led a young man into the presence of the village doctor, "I want you should fix up my son-in-law. I shot him in the leg and lamed him a mite."

"Shame on you, shooting your own son-in-law!" scolded the doctor.

"Wal, doc," replied the old timer, "he warn't my son-in-law when I shot him."

"What makes you think your wife is getting tired of you?"

"Every day this week she's wrapped my lunch in a road map."

The superintendent called in a roustabout to explain to the gang the purpose of a bolt with a left-handed thread.

This was the bewildered reply. "A bolt with a left-handed thread is a bolt which the tighter it's screwed the looser it gets!"

Here lies the body of William Brace;
He sure was one fine fella,
He said in his sleep: "I love, Grace,"
But his wife's name was Stella.

There's no such thing as a small taxpayer.

A fussy old lady was traveling across the country on a bus and was getting extremely angry with the frequent stops.

"Why," she asked the driver, "must you stop at every telephone pole?"

"Sorry, lady," muttered the driver, "but this is a Greyhound."

A certain elderly independent producer, cavorting with a pretty young waitress, evoked the ire of all his friends when he announced he would marry the girl.

"Are you blind? Can't you see she's just after your money?"

"After all the things I bought her," reasoned the old man, "I'm marrying her for my money."

"What becomes of your lap when you stand up?"

'It retires to the rear and pops up under an assumed name."

Two moonshiners were discussing their operations. "When I take the stuff into town," one said, "I always drive slow—about 20 miles per hour."

"Skeered o' the law?" jeered the other.

"Nope," said the first, "ye gotta age the stuff, hain't ye?"

A pretty redhead, window-shopping on Main Street, was being followed by the smooth Latin type. Finally she turned to him and said: "You've been following me for three blocks—I saw you. Just stop it right now. I'm not the type of girl you can pick up."

The suave young man bowed and smiled. "I'm not picking you up, Miss. I'm picking you out." It worked.

Drunk: Ho, lady, you got two ver' beautiful legs.

Girl (snapping): How would you know?

Drunk (brightly): I counted 'em.

Coed: The boy I went riding with last night saw dark spots in front of his eyes.

Roommate: What did he do?

Coed: Parked in one of them.

"Two!" shouted the pint-sized umpire.

"Two what?" snarled the big catcher.

"Yeah, two what?" echoed the equally large batter.

"Too close to tell," said the umpire.

A summer resort is often a pleasant strutting-ground where nobody knows how unimportant you are at home.

Wife: Wake up, Stanley, there's a burglar going through your pockets.

Husband: Leave me out of it. You two fight it out yourselves.

"Your age, please," asked the canvasser.

"Well, now, let me figure it out. I was 18 when I married and my husband was 30. He is now 60, or twice as old as he was then, so I am now 36."

The right voice for telling risque jokes: Guttural.

"Joe has a glass eye."

"Did he tell you about it?"

"No, it just came out during the conversation."

Vacations are simpler nowadays. A man has a wife to tell him where to go and an employer to tell him when. All that is needed now is someone to tell him how.

Mother: Daughter, didn't I tell you not to let that strange man come over to your apartment last night? You know it's things like that, that causes me to worry.

Daughter: Don't be ridiculous, mother. I went over to his apartment. Now let his mother worry.

The cub reporter who was assigned to cover the class plays of the local high school turned up with this write up:

"The auditorium was filled with expectant mothers, eagerly awaiting the appearance of their offspring."

Why is it that ants are supposed to be the hardest workers in the world, yet have time to attend all the picnics?

"Captain, is this a good ship?"

"Why, madam — this is her maiden voyage."

A college graduate is a person who had a chance to get an education.

Tourist: I see you raise hogs almost exclusively around here. Do they pay better than corn and potatoes?

Native: Well, truth is, they don't—but hogs don't need no hoein'.

Cop: There's no red light on the back of your car.

Blonde: Sir! It is not that kind of car!

"Daddy," said the little boy, gazing at the fish in the aquarium,, "how can you tell a boy fish from a girl fish?"

"Well, son, it's all in the worms you use to catch them with," answered his father, "If you bait your hook with a male worm, you catch a female fish. If you use a female worm, of course, you catch a male fish."

"But how can you tell the difference between a male and female worm?"

"Don't ask me," snapped the father. "I only know about fish."

The reporter was interviewing the 103-year-old man.

"Is it true," the reporter asked, "that your 84-year-old son eloped with your house-keeper?"

"I'm afraid it is true," the old man answered soberly. Then he added apologetically, "He's just a crazy, mixed-up kid."

XUM

BOOKS ★

Equilibrium Ratio Data Book, *by NGAA Equilibrium Ratio Committee, E. I. Organick, chairman (United Gas Corporation), Natural Gasoline Association of America, 421 Kennedy Building, Tulsa 3, Oklahoma. Charts, 131. Price, $12.00 with binder ($9.00 without binder).*

This excellent work by the collaborating companies and agencies is the result of several years of work in obtaining the vapor-liquid equilibrium ratios (K-values), from all direct measurement data available, on 15 hydrocarbons from methane to decane, also hydrogen sulfide and hydrogen in mixtures and azeotropes with hydrocarbons. The data were correlated at the University of Michigan under the direction of Dr. George Granger Brown and associates, a group too well known to the industry to require introduction. Data available through 1947 were converted to charts by engineers of the Fluor Corporation, which group also made up the charts on the non-hydrocarbons on data available through 1954. The charts include those developed for pressures of 600 psi to 20,000 psi for most of the hydrocarbons, some of the charts for intermediate pressures for propylene and lighter being absent.

All charts for hydrocarbons are referred to as "Convergence Pressure Charts." The assembly also includes charts showing water content of light hydrocarbon vapors; solubility of hydrocarbons in water; H_2S in ethane and propane (azeotropes), and hydrogen in various hydrocarbons; K-Charts for hydrocarbons and other compounds. Instructions regarding the methods for using the K-charts are included also, along with a reference bibliography.

The edition is available in two forms, the entire assembly in a five-ring loose-leaf binder and the assembly alone, punched for three-ring binders. This is one of the most comprehensive works ever attempted in this field by industry, and presents some of the most valuable data ever assembled, almost indispensable to every engineer in this phase of the industry.

The Chemistry of Petroleum Hydrocarbons. *Volume 1. Edited by Benj. T. Brooks, C. E. Boord, S. S. Kurtz and Louis Schmerling. Reinhold Publishing Corporation, New York City. Hard cloth bound, 664 pages. Price, $18.00.*

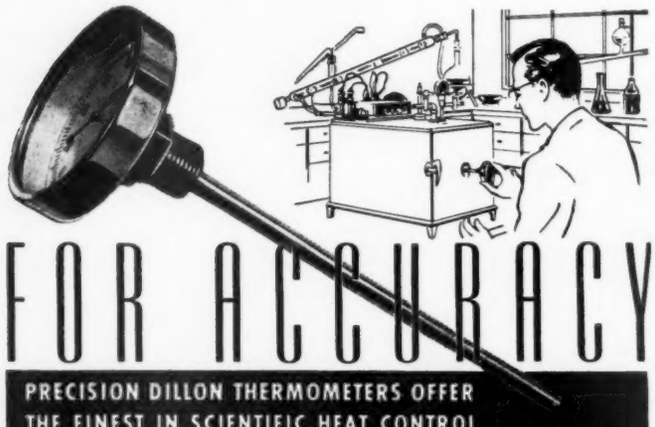
Dedicated to two of the most outstanding hydrocarbon chemical scientists ever produced by the industry, V. N. Ipatieff and F. C. Whitmore, this volume is probably the most concentrated assembly of fundamental facts on petroleum hydrocarbons ever published. Because of the tremendous amount of important research that has been published in this field, the editors found it "necessary to limit its scope largely to scientific fundamentals." The volume includes the fundamental chemistry of many industrial processes that involve hydrocarbon chemistry, and the probable mechanisms of the various reactions are also discussed.

The 21 chapters include discussion in considerable detail of divisions of the field ranging from "Origin of Petroleums," by Brooks, one of the editors, to shale oil, selective solvent extraction, mass spectrometry, hydrocarbon syntheses, petroleum analyses and the composition of shale oils, to mention only a few subjects.

Much tabular data are included, such as, for example, the tables of hydrocarbons found in a single crude, 125 different ones from a single (Ponca) crude. Under "Principles of Solvent Extraction" the critical solution temperatures in various solvents cover nearly nine pages of the book. Use of adducts to separate and concentrate a desired type hydrocarbon is explained in extensive detail for so brief a work. Relationship between molecular structure and the physical properties of hydrocarbons is presented with a wealth of data from original reports in the literature.

Handbook of Engineering Materials, *edited by Douglas F. Miner and John B. Seastone, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Pages 1382. Price, $17.50.*

This is a new reference that covers all branches of engineering. It is published in a consistent and usable format encompassing general information on various materials, with specifications, standards, statistics of application, and mathematical and physical tables. There are sections on metals and non-metals (including wood, paper, plastics, fibers, rubber, organic finishing materials, fuels, lubricants, carbons and ceramics). Data are also included on cements, ropes, timber, glass products, etc., in a construction materials section.



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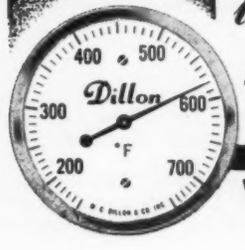

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OIL and GAS TRADE NEWS

The largest gas meter repair center in the Southeast is in Atlanta, Georgia, owned by Rockwell Manufacturing Company. LP-gas meter service is included.

Southeast Meter Repair Center

The largest gas meter repair center in the Southeast was opened in Atlanta, Georgia, recently by Rockwell Manufacturing Company. This new air-conditioned building, adjoining Rockwell's meter and valve division, southeastern regional headquarters, was designed and built by the Ben Massell Companies of Atlanta. Up to 60 persons will ultimately be employed at the new center. Designed primarily for repair and servicing of gas equipment, the one-story brick building will also be used for repair of other products of the division, such as water meters, petroleum and industrial liquid meters, and Rockwell-Nordstrom lubricated plug valves. The center will also be the first major one in this region offering meter repair service for users of liquefied petroleum gas.

Taller & Cooper Expands Section

Major expansion of a special products divsion has been announced by Taller & Cooper, Inc., on the eve of the firm's twenty-fifth anniversary. Among its products, now in use by private industry as well as public agencies, are air pollution detectors and toxic gas controls such as carbon monoxide, hydrogen, and mercury vapor analyzers; weighing and recording instruments, automatic counting and printing systems, and monitoring and telemetering systems for automatic control of industrial processes. Now, all these and other assorted developmental and manufacturing activities are to be consolidated within a single division of the company, separate and distinct from the toll equipment department. The new special products section will be manned by its own research staff in electrical, mechanical, and chemical engineering and will have its own advertising, sales and other administrative personnel.

Schlumberger Opens Field Offices

Schlumberger Well Surveying Corporation has opened two new field locations to serve the Rocky Mountain area. Offices have been opened at Grand Junction, Colorado, under the direction of John Rusen. Rusen was transferred from the Vernal, Utah, location, which has been closed. At Rock Springs, Wyoming, operations have been started with R. E. Kudrle in charge.

Two Distributors Announced

Two distributor appointments have been announced by Baldwin-Lima-Hamilton Corporation, construction equipment division. General Machinery Corporation, Atlanta, Georgia, has been named distributor of Lima shovels, cranes, draglines, and pull shovels, and Austin-Western crushing equipment, covering the northern portion of Georgia with the exception of five extreme northwestern counties. Aldridge-Harbour Equipment Company, Inc., Jackson, Mississippi, has also been assigned the Lima line, covering the southern half of Mississippi. Aldridge-Harbour will also be distributor for Austin-Western crushing equipment.

Switch Firm Acquires Plant

Micro Switch of Freeport, Illinois, a division of Minneapolis-Honeywell Regulator Company, has purchased a multi-story factory building in Freeport, Illinois, that the firm has been occupying for a number of years on a lease arrangement. The 300,000-sq ft building was acquired from the Henney Motor Company and increases to more than 500,000 the total number of square feet of factory space owned and occupied by Micro Switch in Freeport.

Security Opens New Offices

Security Engineering Division has announced the opening of its new offices and warehouse at Lafayette, Louisiana. This new building will house the offices of the Louisiana division manager, the district manager, and office manager as well as the sales and field service staff. Security is a division of Dresser Industries.

Union Carbide's New Home Office

Union Carbide and Carbon Corporation has announced that it has arrived at an agreement to buy an option held by the New York Central Railroad that will enable Union Carbide to purchase the long-term leasehold on an entire block for a new home office site in New York City. Union Carbide proposes to erect on this site in the Grand Central Station area a modern 41-story building for the new home offices of the corporation and its divisions and subsidiaries. The architectural firm of Skidmore, Owings & Merrill has prepared and submitted preliminary plans and sketches. Offices will be fully air-conditioned, and advantage will be taken of the site to provide a maximum of natural light. Employee service facilities will include a completely equipped medical unit, lounge areas, and an employees' cafeteria. It is anticipated that the building project will involve an investment of approximately $40,000,000. The new building is expected to be ready for occupancy some time in 1958.

American Wheelabrator New Name

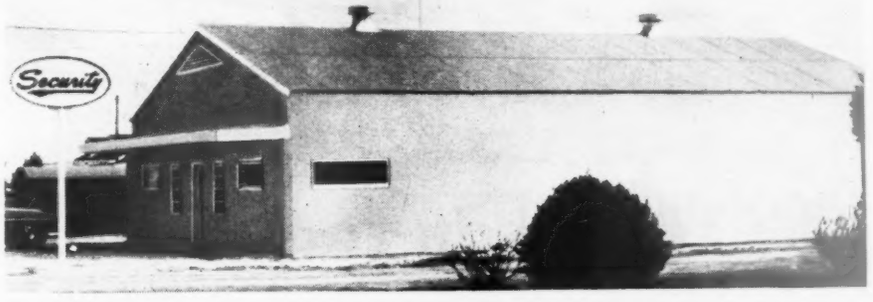
American Wheelabrator & Equipment Corporation, Mishawaka, Indiana, announces that it has changed its corporate name to Wheelabrator Corporation, effective immediately. The move does not involve any alteration in the ownership, management, or operation of the company, which manufactures blast cleaning equipment, dust and fume control equipment, and foundry equipment.

De Laval Names Agent in Eucador

The De Laval Steam Turbine Company, Trenton, New Jersey, has announced the appointment of L. Henriques & Cia., Guayaquil, Ecuador, as its exclusive representative in Ecuador. L. Henriques & Cia. will handle De Laval contrifugal pumps, steam turbines, steam turbine-generators, De Laval IMO pumps, and other products manufactured by De Laval.

Worthington to Handle Karbate

Worthington Corporation will market "Karbate" Brand Centrifugal Pumps manufactured by National Carbon Company, a division of Union Carbide and Carbon Corporation. This distribution will cover motor-mounted (close coupled) and frame-mounted units with capacities ranging from 5 to 1500 gpm at heads to 110 ft at conventional motor speeds.



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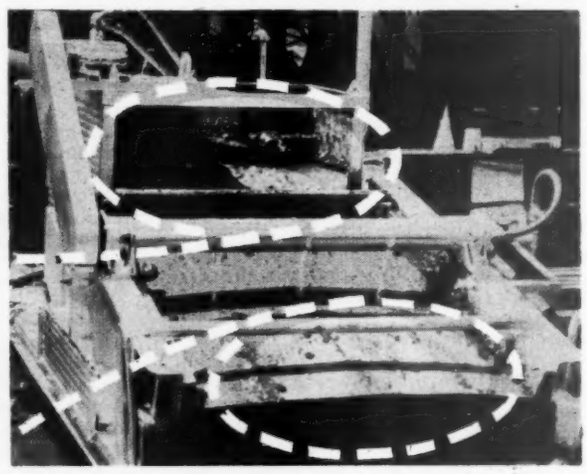

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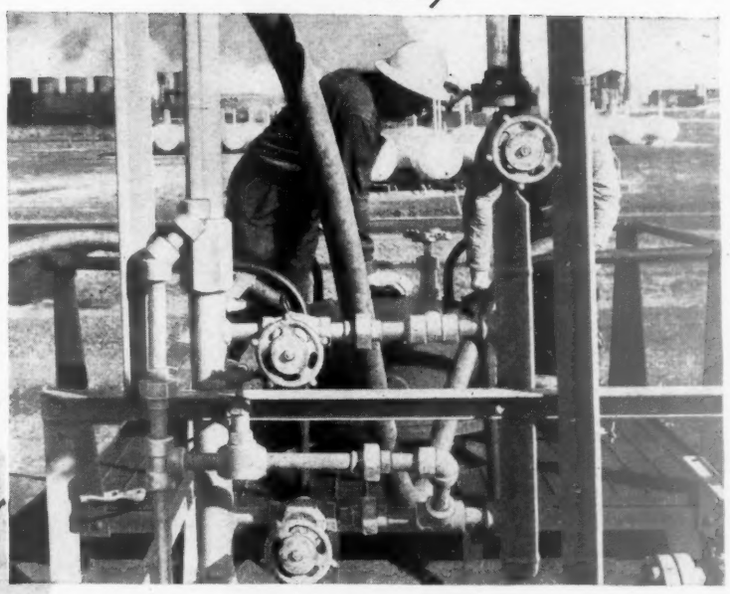
FORGED STEEL FITTINGS



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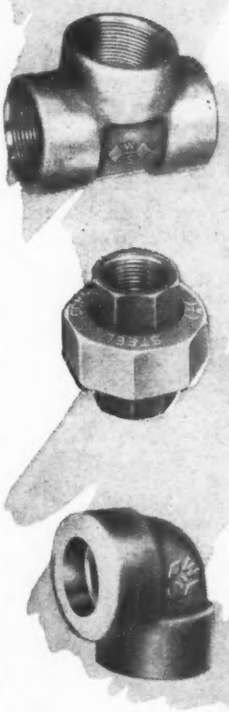

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Protect your high pressure piping system with Watson-Stillman Forged Steel Fittings. Available in carbon, stainless and alloy steels, in Screw-End and Socket-Welding Types to meet your service requirements. Send today for Free Catalogs.

Bulletin A3-50—Forged Steel Fittings
Bulletin S-1-55—Stainless and Alloy Fittings
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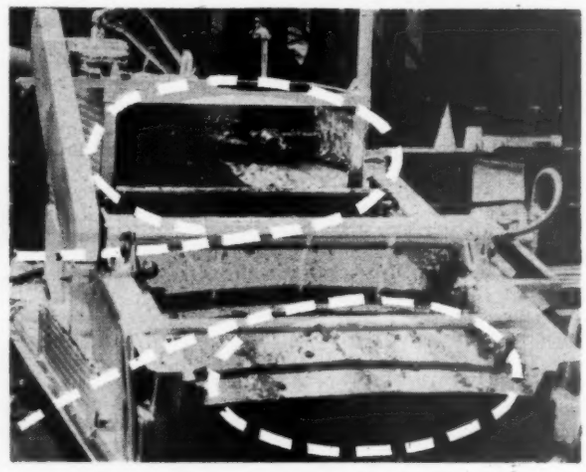

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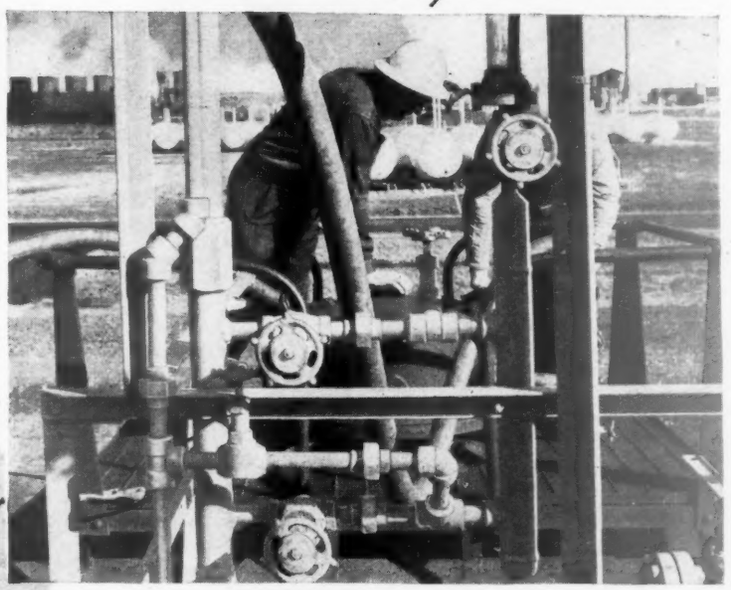

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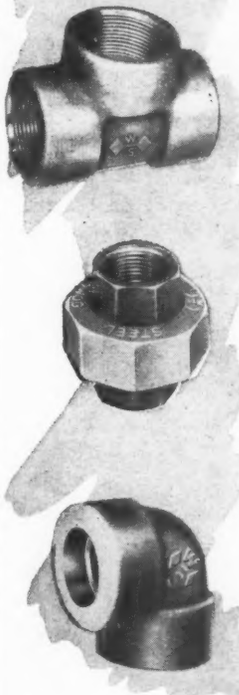

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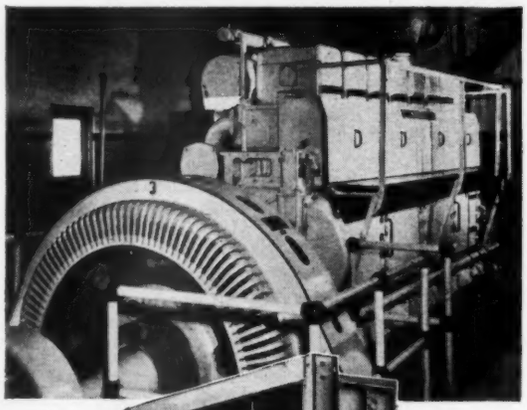
Roselle, New Jersey

To obtain more information on products advertised see page E-51



Nordberg Diesel rated 1060 hp., cooled by Young Radiators

Young Radiator Company Jacket Water Cooler serving Nordberg Diesel

Cool, ventilate, heat

Iowa power plant with YOUNG Mono-Weld radiators

Sioux Center, Iowa Municipal Power Plant has taken full advantage of two Young Radiator Company Jacket Water Coolers used to dissipate engine heat in a Nordberg Supercharged Diesel engine developing 1060 hp.

Rejecting engine heat up to 1,530,000 B.T.U. per hour, the Young Radiators utilize this heat to reduce plant heating costs.

Doors between engine and shutter-equipped cooler rooms may be opened or closed to draw hot air out of engine room in summer for ventilation or deliver hot air for winter plant heating.

Young *Mono-Weld* water cooling capacities range from 500,000 to 2,300,000 B.T.U. per hour. For further details write or call Young Radiator Company today.

Mono-Weld is a Young Radiator Company Trademark

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Catalog No. 1651 provides feature, capacity data and accessory information. Write Young Radiator Company, Dept. 215-K, Racine, Wisconsin.

Young RADIATOR COMPANY

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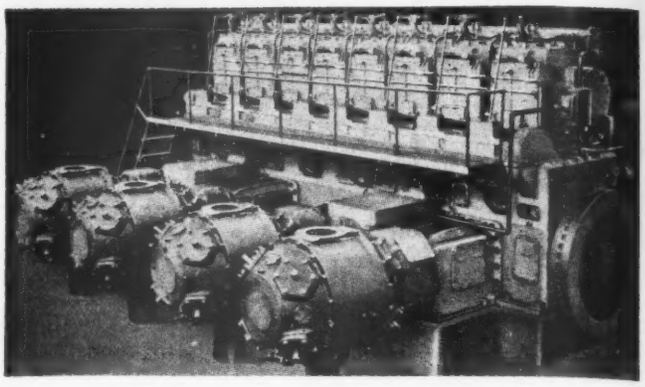
Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY

Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois



How One Refinery Eliminated Scale Build-Up in Compressors

Every six or eight weeks, one petroleum refinery had to run raw acid through compressor water jackets to remove thick lime scale deposits. That meant 12 hours of costly out-of-service time for compressors. What could Oakite do?

First, the Oakite Man descaled the jackets with Oakite Compound No. 32. Then, for preventive maintenance, he charged the spray pond with Oakite Airefiner No. 52, and set up a schedule for maintaining proper pH in the solution.

Results: Manifold temperature reduced—no more descaling, no more cracked blocks or heads, no more compressor downtime.

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Plans for two buildings to house new headquarters for Crane Packing Company near Morton Grove, Illinois, have been made and ground broken.

Crane Plans New Headquarters

Ground has been broken near Morton Grove, Illinois, for two new one-story buildings that will house research and laboratory operations as well as the office and cafeteria for Crane Packing Company. These buildings covering 46,500 sq ft in area are in addition to a 126,000-sq ft one-story factory building, already in operation. When the project is completed early in 1956, Crane will have a new 17-acre home site for its headquarters. Approximately 5000 sq ft of this space will be devoted to laboratory research and testing. Design and development work will be carried on in the electronic, nuclear and similarly rapidly advancing branches of modern industry. Another 32,000 sq ft, entirely air conditioned, will accommodate the sales, executive, and general offices. For the past 35 years, Crane Packing's home facilities have been located in Chicago, Illinois.

ACF Acquires Key Company

Shareholders of Key Company, East St. Louis, Illinois, have voted to accept the offer of ACF Industries, Inc., to acquire Key Company. All property and assets of Key Company are transferred to ACF on the basis of one share of ACF common stock for each four shares of Key capital stock. Thirty thousand shares of ACF common stock are involved in the transaction. Key Company is a manufacturer of high-pressure, high-temperature fittings for oil refineries, chemical plants, and power plants. As such, Key Company will complement the activities of an ACF subsidiary, W-K-M Manufacturing Company, Inc., of Houston, Texas.

Suspension Bridge Monument

Plans are underway for memorial rites at historic Wheeling Suspension Bridge in recognition of the contributions of engineering to the United States, and to the ingenuity of the master bridge builder, John A. Roebling, who redesigned and built the structure in its present form. The initial meeting to formulate plans for the occasion was held recently at the Wheeling Steel Building, attended by a group of prominent engineers, representing the Wheeling Chapter of the West Virginia Society of Professional Engineers and the counterpart of the organization in Ohio, as well as others interested in the project. The memorial will be in the form of a large bronze tablet suitably inscribed and provided by John A. Roebling's Sons Corporation of Trenton, New Jersey. Repairs to the present bridge are planned in order to keep it in use. The memorial ceremony is planned for shortly after these repairs have been completed. The century-old span was constructed during the period when West Virginia still was a part of the state of Virginia.

Cardwell Appoints Dealer

Cardwell Manufacturing Company has appointed The Mt. Vernon Service Parts Company, Mt. Vernon, Illinois, as its new dealer in the tri-state area of Illinois-Indiana-Kentucky. The Mt. Vernon Service Parts Company is owned by Clyde Lackey, Cardwell factory representative in the tri-state area of Michigan-Ohio-West Virginia. Lackey has recently moved to Mt. Vernon from Evansville, Indiana. Prior to joining Cardwell he was district manager for Buda Engine sales and service in the Rocky Mountain area and the state of Kansas. Bob Cable, associated with Cardwell for the past four years, is store manager for Mt. Vernon Service.

Lane-Wells Moves Into Nebraska

The first Lane-Wells branch in Nebraska has been opened at Kimball. It is under the direction of Harold "Slim" Summers, veteran in oil field service, with Harold Karger assisting him. Three new branches have been opened by Lane-Wells in the Gulf Coast division. A sales office was established at El Campo, Texas, and B. A. Jones has been assigned there as district sales engineer. The Beaumont, Texas, branch has been moved to new facilities on West Calder Road. A new truck station has been established on Highway 80 West in Sweetwater, Texas, with J. R. Ross as station superintendent there. The base at Winters, Texas, has been closed and the equipment and personnel transferred to Sweetwater. Another new truck station has been opened at El Dorado, Arkansas. Burt R. Brashier has been transferred from Magnolia, Arkansas, to El Dorado as operator in charge. Ted E. Brisbin, rigman at Wichita Falls, Texas, has been appointed district sales engineer and reassigned to Abilene, Texas.

Power Show to Reveal New Trends

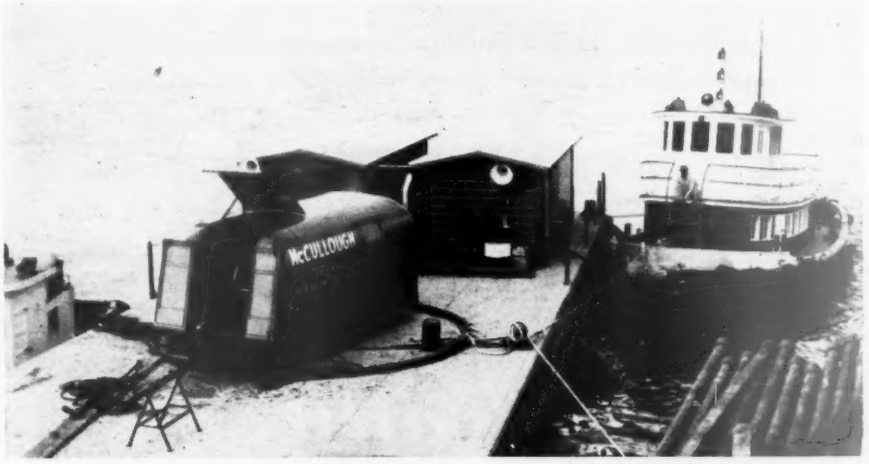
New trends in design will be extensively demonstrated at the Chicago Exposition of Power and Mechanical Engineering, to be held at the Coliseum in Chicago, Illinois, November 14 to 18. The exposition will be held under the auspices of the American Society of Mechanical Engineers in conjunction with its Diamond Jubilee Annual Meeting. Among trends to be revealed at the exposition will be those based on advanced materials and their uses. The atomic power section will be a new feature at the exposition. It has been organized to demonstrate phases of the application of atomic energy to power that are of special interest to mechanical engineers. Several exhibits illustrate the adaptation of conventional engineering equipment to the needs of atomic power plants in the way of heat exchange and the storage and transfer of isolated liquids and gases.

Youngstown Expands Mill

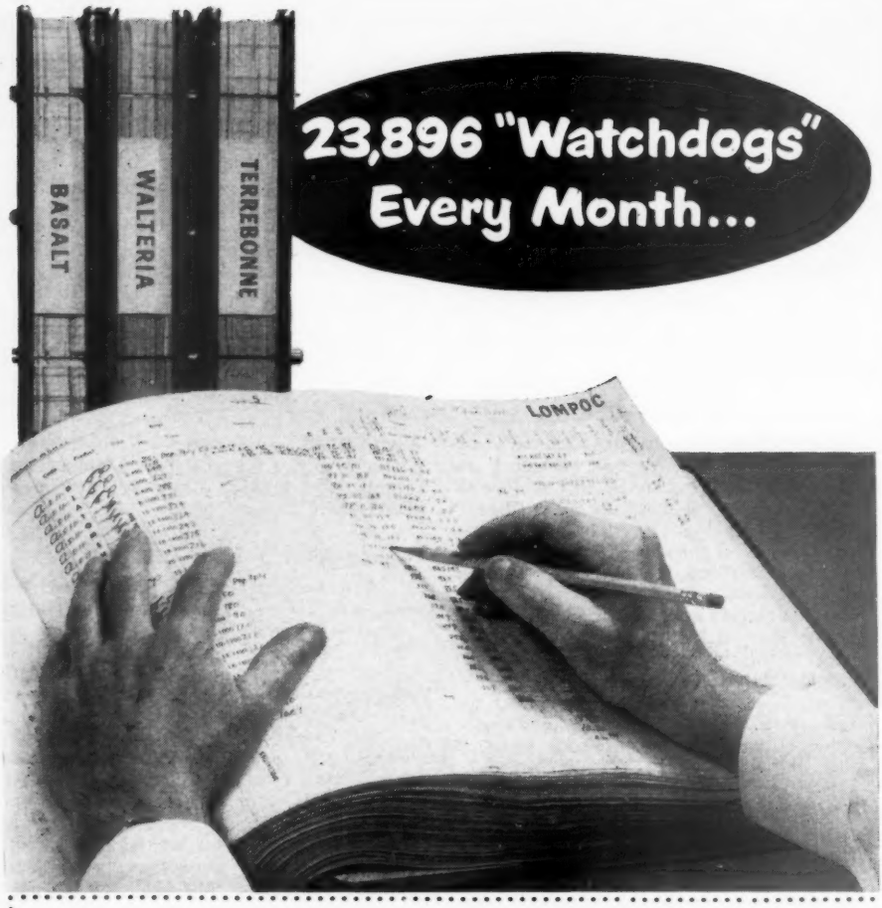
A new battery of 75 coke ovens will be constructed at the Indiana Harbor Works of The Youngstown Sheet and Tube Company, Youngstown, Ohio. The battery is expected to be in operation by September, 1956, and will require about 65 new employees. It will feature underjet-fired combination ovens with additional by-products and benzol equipment and improvements to the existing coal and coke handling equipment. This new battery, to be built by the engineering and construction division of Koppers Company, Inc., will convert approximately 1800 tons of coal into 1250 tons of coke daily.

McCullough Marine Service Unit

McCullough Tool Company has recently completed a versatile marine wire line service unit to meet the requirements of the rapidly expanding offshore drilling program. Designed by McCullough's engineering department and fabricated in the company's Houston, Texas, shops, the new unit revolves on a circular track mounted on a 100-ft by 26 ft barge. Being able to turn a full 360 deg, the unit can efficiently service a well from any desired angle. The service unit has 20,000 ft of wire line and includes electronic equipment and measuring devices to perform all wire line services and radioactive logging. Diesel-powered operation is an important safety factor, eliminating the hazards of gasoline on the barge.



Marine wire line service unit that revolves on a circular track mounted on a barge completed by McCullough Tool.



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Trade News

Yale Opens Detroit Branch

The Yale & Towne Manufacturing Company has added a new sales and service branch in Detroit, Michigan. It is located in a modern, well-equipped 20,000-sq ft building. D. K. Wirth is manager of the new branch and John R. Henderson is sales manager. Hoist sales offices are maintained in the building by Neal Kemp. Prior to assuming the new branch managership, Wirth was president of Michigan Materials Handling Corporation. Henderson previously was special West Coast sales representative of Yale & Towne. He has had 25 years experience in materials handling equipment sales, sales promotion, and engineering. Kemp has been Yale hoist representative since 1951. Six thousand square feet of the branch building are allocated to a spacious display area and sales and administrative offices. Of the remainder, one half is devoted to shop service facilities and the other to a complete service parts stock room and storage of new and used trucks.

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NOTICE

ANTI-TRUST CASE SETTLED. After extended negotiations, upon consent of the parties and without trial of the case, upon April 7, 1955, a final judgment was entered in the case of United States of America vs. Magcobar, Inc., Dresser Industries, Inc., Clarence J. Coberly, Dresser Equipment Company and Kobe, Inc., Civil No. 13460-BH. Under the terms of this judgment, Kobe, Inc., is required to grant licenses under its patents relating to hydraulic oil well pumps on a reasonable royalty basis. A list of such patents and a copy of such final judgment will be furnished upon request to Kobe, Inc., 3040 East Slauson Avenue, Huntington Park, California.

Porter Buys Electronics Firm

The Electric Service Engineering Company, Joliet, Illinois, has been purchased by H. K. Porter Company, Inc. "Eseco," the trade name for Electric Service, specializes in the design and manufacture of complex electrical and electronic devices used in heavy industry and in certain government departments, including the armed forces. It will be known as the Eseco division, the Porter Company, and is the thirteenth within the Porter organization. The present management of Eseco will continue with the new division. R. J. Cadorette, former president, will be executive vice president in charge of operations. B. F. Pfeifer and R. W. Dixon will be vice presidents in charge of sales and engineering respectively.

Eseco manufactures products closely allied with equipment manufactured by Porter's Delta-Star Electric Division, Chicago, Illinois. There is a possibility of combining the sales efforts and certain manufacturing functions of the two divisions.

Plane Lease Company Formed

Something unique in the way of business flying is now offered by Executive Flyers, Inc., an executive aircraft lease company. Business concerns may have the per-hour use of modern, single-engine and multi-engine planes complete with crews on a lease basis. The company, based at Southwest Airmotive in Dallas, Texas, plans to continue expanding its initial pool of six aircraft and crews. This per-hour lease arrangement was planned especially for corporations that occasionally or regularly need planes but do not desire to incur the expense of owning a plane and paying crew salaries, hangar rentals, and maintenance costs. All flights are to be made in finely maintained aircraft and in strict conformity with CAA regulations. Owners are Col. D. Harold Byrd, one of the earliest operators of a business airplane in the U. S.; Robert A. Lyle, chief pilot for Colonel Byrd for the past nine years, and Charles R. Pate, Jr., another former member of the Byrd Oil Corporation aircrew.

New Distributors for LeTourneau

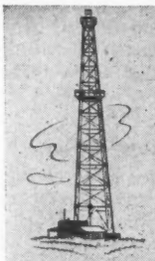
Three new distributors have been appointed by R. G. LeTourneau, Inc., for its line of equipment. The new Brazilian distributor is Serva Ribeiro, S. A. (Sociedade Tecnica e Commercial Serva Ribeiro, S. A.), with offices in Sao Paulo and Rio de Janeiro. Products handled will include land-clearing equipment, logging equipment, and industrial units such as jib cranes and electric hoists. For many years the Brazilian firm has handled heavy equipment used in construction, agriculture, and industry. W. E. Richardson Machine Company, Inc., has been appointed distributor of electric hoists and jib cranes for the Alabama area. It is the first such distributorship taken on by the Richardson company since it was founded in 1912. Primarily his firm is a manufacturer of custom industrial machinery. The Richardson firm is located in Birmingham. Vetcoa Supply Corporation, Phoenix, Arizona, has been appointed distributor of electric hoists and jib cranes for the Arizona area. Vetcoa is a newly organized firm, owned and operated by the owners of Vernon Tool Company of Arizona. The latter for some years has been doing contract precision machine work for such concerns as Motorola, Inc., AiResearch Manufacturing, Goodyear Aircraft, Cummins Engine.

Allis-Chalmers Expands in Iowa

A $1,800,000 expansion program for the shops and offices of the Cedar Rapids, Iowa, Works, Allis-Chalmers Manufacturing Company, has been announced. The company's motor scrapers and motor wagons are made at the Cedar Rapids Works. Expenditure includes amounts allotted for new buildings as well as for machine tools. Enlarging of the shops and offices is expected to increase productive capacity by 50 per cent. When the program is completed, several hundred people will be added to the present work force. The program is scheduled for completion in early 1956. It will include the erection of new buildings and some replacement of old ones. The main office building will be enlarged and a new experimental and engineering lab erected.

Two Canadian Firms Join Forces

The Warnock Hersey Company, Ltd., and Canadian Inspection & Testing Company, Ltd., have recently joined forces. Both companies will continue to operate under their original names and with the same staffs. The Warnock Company, believed to be the largest such organization in Canada, maintains a head office and main laboratories in Montreal, Quebec, and branch offices and laboratories from coast-to-coast. It serves the construction, manufacturing, railroad, pulp and paper, petroleum utilities, and many other fields. The head office and main laboratories of Canadian Inspection & Testing are located at Toronto, Ontario. Its work is somewhat similar to that of Warnock Hersey, with most of its activity in the construction and transportation fields.



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Baltimore, Md.—Ted Barto, 2301 No. Charles St.
Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Detroit, Mich.—Thomas L. Osberger, 10226 Woodward Ave.
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Houston, Tex.—Henry H. Paris Distributor, Inc., Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Avenue
Milwaukee, Wis.—M. A. Nelson Co., 3347 N. 97th St.
Minneapolis, Minn.—Lin J. Krause, 5605 Lyndale Ave. S.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., Industrial Office Bldg., 1060 Broad St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Mike A. Boyle Co., 1112-18 Hamilton Ave.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
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WHEELING, WEST VIRGINIA
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To obtain more information on products advertised see page E-51

Trade News

California District Office

Texas Instruments, Inc. is opening a Los Angeles, California, sales office as the first step in establishing marketing headquarters throughout the U. S., the company has announced. The Los Angeles office will be headquarters for the western district and is the first of several offices scheduled to be opened this year. The 25-year-old electronics firm previously marketed its products and services mainly with the aid of sales representatives based at company headquarters in Dallas, Texas, and with only a few specialized representatives in the larger cities. New district offices will be staffed with representatives of Texas Instruments' manufacturing divisions.

Baroid Opens New Area Offices

Baroid division, National Lead Company, has announced new Pacific Coast area offices at 3113 26th Street, Los Angeles, California. E. L. Mohr, Jr., is manager for the Pacific Coast area and L. T. Weber, Jr., assistant area manager. A new Denver, Colorado, office has been opened as headquarters for the Rocky Mountain area for Baroid. F. E. Palmer has been appointed manager for this region, with W. E. Gorham as assistant area manager. New Orleans has been designated as headquarters for Baroid's Louisiana Gulf Coast area. K. K. Litman has been named area manager. Baroid's office in Tulsa, Oklahoma, is now operational headquarters for the newly designated Mid-Continent area. Jack H. Beesley is the manager for the Mid-Continent area, and B. L. Boccella has been appointed assistant manager.

New Division for J&L

The Jones & Laughlin Steel Corporation supply division has established a new district sales office in the Hibernia Bank Building in New Orleans, Louisiana. Clarence E. Rogers, the division's Louisiana Gulf Coast district sales manager, will maintain office headquarters there, with Bill Wood as salesman for the New Orleans area. A newly organized sales office, under the name of Jones & Laughlin Steel Sales Company, Ltd.—Supply Division, has been established in the Metropolitan Building, 1846 Scarth Street, in Regina, Saskatchewan, Canada. H. Carl King, who has served as the division's resident sales representative in Regina for the past year, will maintain headquarters at the new sales office and will continue to serve the oil industry in the provinces of Saskatchewan and southeastern Manitoba.

New Sales Office Set Up

Fischer & Porter Company has established a district sales office at 607 Montana Street, El Paso, Texas. Charles Allen has been named district manager. The El Paso sales territory comprises New Mexico and most of Texas west of and including San Angelo.

Rolls-Royce Signs Twin Disc Pact

Rolls-Royce, Ltd., of England, has signed an engineering license agreement with the Twin Disc Clutch Company, Racine, Wisconsin, under which the former will manufacture in England torque converters of Twin Disc design. Torque converters made under this agreement will be used with Rolls-Royce industrial oil and gasoline engines powering crawler tractors, rail cars, switching locomotives, off-highway trucks, and similar heavy-duty equipment. The agreement also provides for interchange of technical information relating to design, manufacture, and application of torque converters.

Perkin-Elmer Opens New Office

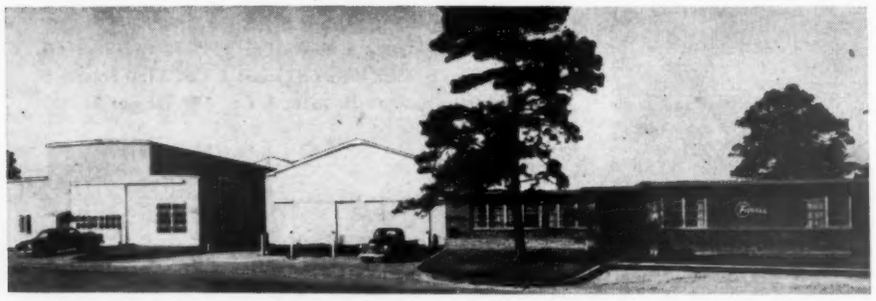
A new regional sales office to serve the western and northwestern states has been announced by the Perkin-Elmer Corporation. New office, opened August 1, is located in the Citizens National Bank Building, North Marengo Street, Pasadena, California. Personnel of the new office will include Winston C. Loe for sale of process control equipment, Thomas A. Guerin for the sale of laboratory instruments, and Albert W. Ehm, who will be the service engineer.

Panellit Announces New Division

Panellit, Inc., has announced formation of the new instrument services division to fulfill demands for engineering facilities outside the normal range of company activities. The new division will provide consulting and installation services in the field of instrumentation and automation. Neil M. Blair has been appointed manager of the division.

Distributor for Nordberg Diesels

Appointment of Lively Equipment Company, Albuquerque, Mexico, with its affiliate Lively Equipment Company, El Paso, Texas, as distributor for Nordberg Power Chief diesel engines has been announced by the Nordberg Manufacturing Company. Their area will include El Paso, New Mexico, and northeastern Arizona.



As part of a general expansion program covering both its manufacturing and sales facilities, the Farris Engineering Corporation, and its affiliates, Palisades Park, New Jersey, has announced establishment of a new plant in Houston.

The modern, air-conditioned unit shown in photograph is equipped with all necessary facilities for the manufacturing and servicing of all equipment in the Farris line. Promoted to manager of the new Farris Houston plant is Edward Groth, Jr.

Delta Tank Has New Furnace

Delta Tank Manufacturing Company, Baton Rouge, Louisiana, has placed in operation a new stress-relieving furnace that is one of the largest in the South. This new 75-ft long gas-fired furnace is planned to enable the company to produce higher quality pressure vessels and a wider range of products for the petroleum, chemical, and petrochemical industries. The new furnace, heated to 1300 F temperatures by a series of gas jets, will accommodate vessels in single heats of 13 ft 6 in. in diameter, by 72 ft 6 in. in length. Varying lengths above the 72-ft capacity are handled by multiple or sectional heatings.

New Distributors for Ampco

Kencroft Associates, Inc., Buffalo, New York, and Ontario Metal Supply, Inc., Rochester, New York, have been franchised to distribute standard Ampco Mill and Foundry Products in their respective trading areas by Ampco Metal, Inc.

New Yale and Towne Outlets

The Yale & Towne Manufacturing Company has announced the establishment of two additional representatives in Indiana and Illinois. New outlets for Yale industrial lift trucks are the Kimball Industrial Sales Corporation, South Bend, Indiana, and the H. W. Carpenter Company, Peoria, Illinois. Jere Kimball heads the Indiana operation and Harry W. Carpenter is in charge of sales in Illinois. Both the new Yale installations will feature complete service facilities with trained personnel and stocks of factory parts.

Division Products Switched

The Pittsburgh Coke & Chemical Company has announced the addition of specialty tars, coal tar pitch, and creosote to the products manufactured and sold by its protective coatings division. These materials were formerly handled by the company's coal chemical division. In addition, further emphasis will be placed on Pittsburgh's program of upgrading basic coke oven-derived materials and of developing new products from these materials. This accelerated technical program will be conducted by the research laboratory for the protective coatings division. This move will permit the company's coal chemicals division to concentrate on and accelerate its steadily growing production and sales program in the field of industrial chemicals, such as phthalic anhydride, maleic anhydride, and phenol.

New Pritchard Representative

Tate Engineering & Supply Company, Inc., Baltimore, Maryland, has been appointed sales representative for the state of Maryland by J. F. Pritchard and Company of California. The hydraulic division of Tate Engineering will handle the sale of Pritchard equipment in conjunction with the process equipment of other manufacturers.

Shaffer Tool to Build New Shop

Shaffer Tool Works has announced that the company will begin immediate construction on an office and warehouse building in Oklahoma City, Oklahoma. Clay Fry will be the Oklahoma City manager.

The new building will be located on the corner of 62nd Street and Shields Blvd. on Dallas-Oklahoma City Highway 77.

TRADE PERSONALS

E. M. Gearke

O. B. Avent

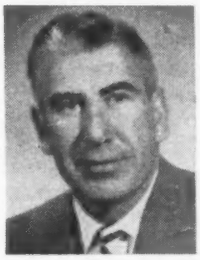
E. M. (Ed) Gearke has been made Gulf Coast area sales manager for Baash-Ross Tool Company, division of The Joy Manufacturing Company, with headquarters in Houston, Texas. He held an executive position with the Trident Drilling Company in Calgary, Alberta, Canada, before assuming his new job.

O. B. Avent has been named a vice president of Welex Jet Services, Inc. Avent, who is in charge of all the company's field operations, had been operations manager since he moved to Fort Worth in 1954. He attended Oklahoma City University and Oklahoma A&M. **Albert E. Stringer** has been appointed sales engineer for the Ardmore, Oklahoma, district office of Welex Jet Services. Stringer has been with Welex in various positions for seven years. **Jack E. Brown** has been made assistant manger of the new Welex district office at Farmington, New Mexico. Brown, a graduate of the University of Oklahoma, has been with Welex for over three years. **Jack P. Pouland** has been named Kansas sales representative. Before appointment to his new post, Pouland was district manager of the Welex office in Great Bend, Kansas. A native of Houston, Texas, he attended Texas &. & M. College. **Claude "Doc" Alexander** is now sales engineer for the Welex district office in Winfield, Kansas. Alexander has been with Welex for two years and had worked as a rigger and shooter prior to his promotion.

Maurice Webb has been transferred from Houma, Louisiana, to Lafayette, Louisiana, for technical Oil Tool Corporation's field service to replace **Don Gibbs,** who was recently killed in an auto accident. **Bobby L. Howard** has taken over Webb's former duties at Houma and Harvey, Louisiana. **S. W. Stafford** has been employed for the Pratt, Kansas, area. **R. G. "Bob" Willson** has been stationed at Farmington, New Mexico, replacing **Bob Scott,** who recently died. **William R. Webb** will serve at Bakersfield, California.

E. B. Van De Mark has been appointed manager, production control, and **Edward Hauprich, Jr.,** manager customer service, at the Watervliet, New York, plant of Allegheny Ludlum Steel Corporation. Van De Mark joined the company in 1936 and was order manager at Watervliet prior to his new appointment. Hauprich, who started with the company at Watervliet in 1934, was assistant order manager at that location.

E. B. Hill has been appointed to the newly created position of assistant to the president of the Koehring Company. He was vice president and director of sales, advertising, and export sales for Gar Wood Industries, Inc., when he resigned to join the Koehring organization. **Howard H. Mobley** has been named district representative for Koehring's East South Central territory. Mobley has been active in various phases of general construction work since 1930. **William B. Thompson** has also been made district representative by Koehring. Thompson joined the Koehring Company earlier this year. He is a mechanical engineering graduate of the University of Oklahoma and has had valuable construction work experience working with state highway departments. His background also includes work as a salesman and as a sales engineer for The Allis-Chalmers Manufacturing Company.



W. F. McNaughton

E. B. Hill

Walter F. McNaughton has been appointed national sales manager for Plicoflex, Inc. McNaughton has been engaged in the manufacture and sale of corrsion-resistant plastic tapes for the past eight years. Before that time he served as assistant material control supervisor for the Dodge plant in Chicago, Illinois.

R. J. Granberry

R. C. Wilshusen

R. J. Granberry has been made district manager of Core Laboratories, Inc., for the Upper Gulf Coast operations with headquarters in Houston. Granberry is a member of Core Lab's board of directors and has served as district manager in Corpus Christi, Texas, for the past eight years. He joined the firm in 1941, following his graduation from Louisiana State University, where he received a degree in geology. His new assignment follows the recent resignation of **Ben A. Elmdahl. R. C. Wilshusen,** Oklahoma City, Oklahoma, has been promoted to district manager of the Corpus Christi area. He was graduated from SMU with a degree in mechanical engineering. Wilshusen has served as assistant district engineer in the Oklahoma-Kansas area since 1951.

Edward G. Kominek has been promoted to the position of general sales manager of Infilco, Inc., after being assistant sales manager since 1950. Kominek has been with the company since 1937 when he joined it as a research chemist.

L. D. Snyder

E. G. Kominek

Lenard D. Snyder has been made chief engineer, oil field products, for Joy Manufacturing Company, with headquarters in the company's plant in Dallas, Texas. Snyder was graduated with a dregree in mechanical engineering from Oklahoma A&M College. He has been associated with George E. Failing Supply Company, Continental Oil Company, and Drilling Accessory and Manufacturing Company. He is a registered professional engineer in the state of Oklahoma.

William A. Moore, district representative for U. S. Steel's Oil Well Supply division, has been transferred from Huntington Beach, California, to Long Beach, Californa. Oil Well has appointed the following field representatives: **Acy Carl Dulaney,** Odessa, Texas; **Raymond F. Steward,** McCamey, Texas; **Dewey M. Clark,** Hobbs, New Mexico; **Raymond H. Miller,** Medicine Lodge, Kansas; **Vernon D. Taylor,** Gainesville, Texas; **Ollian Fugler,** Houma, Louisiana, and **Dewey A. Bond,** Borger, Texas. New store managers have been named as follows: **Harley A. Harris,** Worland, Wyoming; **Arthur F. Fiensy,** Mt. Carmel, Illinois; **Willie J. Reeves,** Brookhaven, Mississippi; **Lewis Y. Poland,** Medicine Lodge, Kansas; **Allen C. Heard,** McCamey, Texas, and **Francis B. Mobley,** Odessa, Texas.

John Grubb has been appointed manager of the newly formed international division of Cameron Iron Works, Inc. This new division is comprised of the present Cameron Iron Works of Canada, Ltd., the British Oilfield Equipment Company, Ltd., in England, the Cameron Export Division in New York City, and all other manufacturing and sales offices outside the United States. Grubb was formerly director and general manager of National Supply Company of Venezuela. He attended Marquette University and Iowa State College.

William Bohrer will now be associated with Wheelco Instruments division, Barber-Colman Company, in the Wheelco Cleveland, Ohio, office as a sales engineer. **Vincent Piedmonte,** formerly of the Cleveland office, is now Wheelco branch sales manager at the Barber-Colman, Ltd., of Canada office in Toronto. **James Hind** has become a sales engineer with the Syracuse, New York, office. **Glenn Fann** has been added as a service engineer in the Rockford, Illinois, area.

Howard G. Crider has been appointed distributor of oilfield lubricants in the Ardmore, Oklahoma and Wichita Falls-Sherman, Texas, area for Jet-Lube, Inc.

50% heavier line

For longer service

LUFKIN "ATLAS"

CHROME CLAD OIL GAGING STEEL TAPE

Extra-Duty Line — 50% heavier than standard.

Chrome Clad non-glare, durable finish is corrosion resistant — will not crack, chip, peel.

Jet Black Markings stand out against chrome white background.

Also available in black finish with Bright Markings for use in light oils.

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Case-hardened Frame for longer wear.

Solid Brass 20-ounce Plumb Bob penetrates heavy oils.

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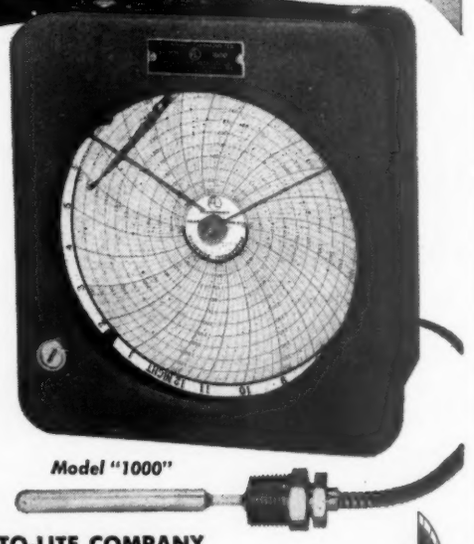

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INSTRUMENT AND GAUGE DIVISION
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TEMPERATURE RECORDERS

Trade Personals

Clinton B. Burnett has been appointed general manager of the Johns-Manville Corporation celite division. Burnett succeeds **Arthur S. Elsenbast,** a pioneer in the development of manufacturing methods and uses of diatomite products, who retired recently. Burnett, who will continue as vice president of Johns-Manville Products Corporation, was director of engineering before his appointment as assistant general manager of the celite division in 1954. He joined Johns-Manville in 1931 at the company's plant in Waukegan, Illinois. Burnett is a graduate of Washington University, St. Louis, Missouri, and studied law at Kent College. Elsenbast joined the Celite Company of New York City as a research chemist in 1917. He was appointed vice president of Johns-Manville Sales Corporation in 1937 and made general manager of the celite division in 1946. In 1951 he was named vice president of Johns-Manville Corporation. Elsenbast is a graduate of Cornell University.

Charles A. Wallace has been appointed manager of the Industrial Filtration division of the United States Hoffman Machinery Corporation. Formerly assistant division manager, Wallace has been with the company 24 years. He previously had been a machine tool engineer and before that an automotive engineer. He is a graduate of the Massachusetts Institute of Technology.

William H. Stahlheber and **Jack F. Eckelaert** have been appointed to sales department positions in the home office of the Trane Company at La Crosse, Wisconsin. Stahlheber, an engineering graduate of Washington University, has joined Trane as assistant to the manager of the process heat transfer department. He has been associated for several years with the Atomic Energy Commission project at Oak Ridge, Tennessee, most recently as a development engineer. Eckelaert has been named to the company's unit heater sales department. He is a graduate of the University of Wisconsin with a bachelor's degree in mechanical engineering.

Bernard F. Gilligan has been named sales manager, process plants division, Gulf Coast district, Foster Wheeler Corporation. Gilligan will make his headquarters in Houston, Texas. A graduate of Stevens Institute of Technology with a degree in mechanical engineering, Gilligan has been project manager for a number of refinery projects built by Foster Wheeler in the U. S. and Europe. Foster Wheeler equipment division sales in the Gulf Coast area will continue to be handled from the Houston office by **Wilson Pais,** who has been appointed manager of equipment sales.

D. A. Cameron, industrial sales manager of The Parker Appliance Company for the past several years, has been appointed general sales manager of the company's three industrial divisions, Tube and Hose Fittings, Rubber Products, and Industrial Hydraulics. Cameron received his degree in business administration from Western Reserve University. He was appointed assistant general sales manager in 1946 and was later named industrial sales manager, the position he has occupied since.

Charles B. Sanborn has joined the electroplating section of Development and Research division of The International Nickel Company, Inc.

Paul A. (Al) Puckett has been made sales manager, Mid-Continent region, for Axelson Manufacturing Company, division of U. S. Industries, Inc. He succeeds **Ken S. Ramey,** who has been transferred to Los Angeles, California, as sales manager, petroleum equipment division. Puckett has been assistant manager in Tulsa, Oklahoma since 1954. He joined Axelson in 1945 and attended the University of Arkansas.

Paul A. Puckett

George S. Trees, a director of Chicago Bridge & Iron Company, has been made manager of the company's Pittsburgh, Pennsylvania, sales office. He succeeds **George S. Sangdahl,** who died recently. Trees has been in the employ of Chicago Bridge & Iron since 1936 and had been assistant general sales manager since 1954. Additional changes include the following transfers from the general sales office in Chicago Illinois. **Theodore F. Cocks,** Chicago; **Jack W. Schultz,** Salt Lake City, Utah, and **Richard E. Croop,** Boston, Massachusetts.

B. C. Sears, has become Great Lakes regional manager, with headquarters at Cleveland, Ohio, for Cummins Engine Company, Inc. Sears is a graduate of Purdue University with a degree in mechanical engineering. He joined Cummins in 1946 as a junior test engineer. Earlier this spring, he was named regional manager, Rocky Mountain region, at Denver, Colorado, a position he held until his latest assignment.

James P. McNally has been chosen sales manager of Bart Manufacturing Corporation. He has been with Bart Manufacturing for the past year. An alumnus of Syracuse University and the University of Wisconsin with a major in metallurgical engineering, McNally has also served the corporation in the capacity of metallurgical technical adviser. Previously he was affiliated with the Carrier Corporation as production metallurgist.

I. H. Munro has been named vice president of Solvay Process division, Allied Chemical & Dye Corporation. Munro is a graduate of Colgate University and holds a master's degree in chemical engineering from the Massachusetts Institute of Technology. He joined Solvay's engineering department at Syracuse, New York, in 1935 and was appointed assistant to the executive vice president in 1953.

H. M. Shearin has been added to the staff of Core Laboratories, Inc., Dallas, Texas, as a senior petroleum engineer in the reservoir engineering and consulting department. A chemical engineer graduate of Rice Institute, he previously had been employed in field evaluation and unitization work with Humble Oil & Refining Company in Houston, Texas. His experience also includes training with Gravity Meter Exploration Company and the U. S. Corps of Engineers.

L. E. "Ed" Wallace has been appointed to the position of sales manager for Orbit Valve Company. Wallace previously was Orbit district manager at Houston, Texas, and will be succeeded there by **Ralph H. Soape,** assistant manager. Wallace joined Orbit in 1946 as a field salesman. In 1951, Soape also joined Orbit Valve as a field salesman.

L.O.F. Glass Fibers Company has appointed three regional sales managers and two district sales managers. **Thomas L. Carver** has been named sales manager of the Eastern region, with headquarters in New York City. **John B. Banks** has been appointed sales manager of the Central region, and he will headquarter in Detroit, Michigan. **Robert E. Simpson** has been made sales manager of the Southwest region, with headquarters at Houston, Texas, and **Robert H. Heyman** is the new district manager of the Dallas, Texas, area. In the Midwest region, **Arthur S. White** was assigned as district manager at St. Louis, Missouri, and **Norman C. Plass,** district manager at Minneapolis, Minnesota.

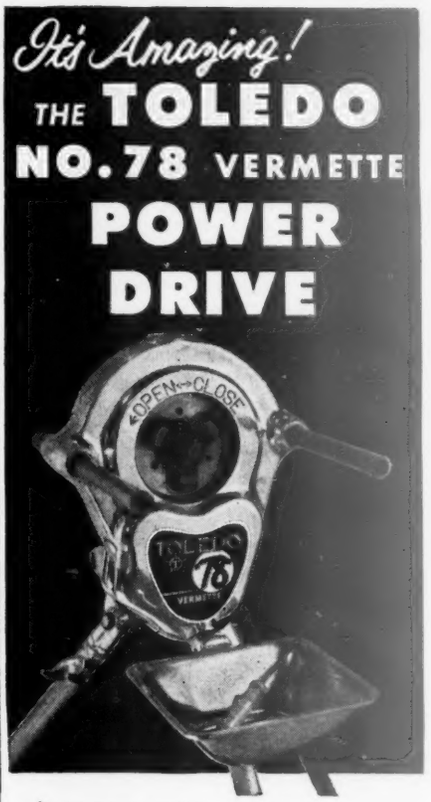
William L. Pharmer has been appointed assistant sales manager of the electro dynamic division of General Dynamics Corporation. Pharmer, a graduate of Tri-State College, Angola, Indiana, in Electrical Engineering, has been engaged in the application and sale of electrical rotating equipment for the past fifteen years.

W. L. Pharmer

Robert D. Stottlemyer has been appointed division manager of the Northwest division of The National Supply Company. He succeeds **Kenneth O. Hoevel,** who was transferred to the Midwest division. Stottlemyer joined the company in 1946 as a drilling equipment engineer and became assistant division manager in 1952, with headquarters at Casper, Wyoming. He was graduated from the University of Pittsburgh as a petroleum engineer and was employed by the Gulf Oil Company prior to joining National Supply. Hoevel has been appointed division manager of the Midwest division succeeding **Denzel G. Mann,** who has retired. Hoevel began work with the company in 1935 as a store clerk and served as division sales manager of the Midwest division from 1944 to 1953, when he was promoted to division manager of the Northwest division. Hoevel attended the University of Tulsa and received a degree in mechanical engineering at the Missouri School of Mines.

Walter A. Reynolds has been named district manager of The Garlock Packing Company's Denver, Colorado, office succeeding **M. J. Lester,** retired. Reynolds was first employed by Garlock as shipping clerk in the Boston, Massachusetts, office in 1927. He was sales representative in lower Michigan and northern Indiana from 1952 until his recent transfer.

M. L. (Mike) Ferguson has been transferred from direct field service to sales with Stewart & Stevenson Services, Inc. in Houston, Texas. He will act as liaison man between the field service and sales and engineering departments. Ferguson has been employed by Stewart & Stevenson since 1945. **Bill Powell** has also been transferred to the Houston sales office, where he will concentrate on petroleum industry engine sales. He has been employed by the company since 1946.



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Grips like a pipe wrench—self centering

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Trade Personals

C. F. Ludwig has been named acting division manager of Lane-Wells Company's Pacific Coast division replacing **J. W. McPhee,** who has resigned. Ludwig has been with Lane-Wells 18 years and has held positions in all three of its domestic divisions and Lane-Wells Canadian Company. From 1949 to 1951 he was vice president of Lane-Wells Canadian Company. Since July of 1951, he has been assistant manager of the company's Pacific Coast division.

Trebor B. Morris has joined the Chicago Pneumatic Tool Company as chief metallurgist for the oil tool division at the Fort Worth, Texas, plant. Morris was previously with American Iron and Machine Works and prior to that was associated with the Reed Roller Bit Company.

Perry L. Francis, former vice president in charge of sales, has been elected vice president in charge of marketing of Alan Wood Steel Company. **William E. Boger,** formerly general superintendent, has been named vice president in charge of operations. **Howard W. Read,** formerly comptroller and assistant treasurer, has been selected as vice president and comptroller. Francis has been associated with Alan Wood Steel for 31 years; was elected vice president in charge of sales in 1949. Boger has been identified with the steel industry since 1924 when he joined Republic Steel Corporation at its Warren, Ohio, plant. He became associated with Alan Wood Steel in 1950 as superintendent of the company's new hot rolled strip mill. He was appointed general superintendent in 1954. Boger attended Ohio State University. Read began work with Alan Wood Steel in 1937 in the metallurgical department. He was graduated from Princeton University with a BA in economics.

C. L. Griffin, sales manager, for the American Iron and Machine Works Company, Inc., of Oklahoma City, recently returned from an extended tour of Europe, which included oil country tubular goods contacts and oil tool manufacturers in Italy, Germany, Holland, France, and England.

C. L. Griffin

The main purpose of Griffin's trip was to assist the Dalmine Steel Mill of Dalmine, Italy, in the engineering, tooling, and manufacturing procedures of the American Iron Straight Grip pipe threads that they have been licensed to turn.

S. N. Campbell has been assigned to the Houston, Texas, sales office of The Cooper-Bessemer Corporation. He spent a period of time in the Los Angeles area before his present appointment. Campbell is a University of Texas graduate. **W. H. Kraemer** has been appointed to the company's branch sales office in Los Angeles, California. Kraemer's first assignment was to the concern's San Francisco, California, office in 1950. He is a graduate of Purdue University.

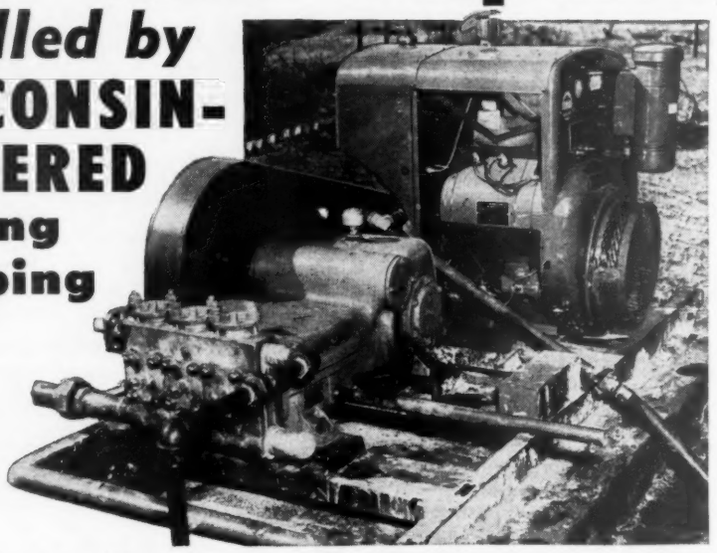
F. LeBus, Jr.

Frank LeBus, Jr., has just returned from a business trip to France, Germany, Holland, and England where he set up distributorships for products manufactured and sold by LeBus Rotary Tool Works and LeBus International Engineers, Ltd., of Longview, Texas. Mrs. LeBus accompanied her husband on the European trip.

W. James Latimore has been appointed an assistant director of sales of the Du Pont Company's Grasselli chemicals department, to succeed **Wallace E. Gordon.** Gordon has become director of Du Pont's advertising department. Latimore will have supervision of biological chemicals sales and development and also of export sales. Chicago district sales manager since 1952, Latimore first became associated with the Grasselli sales organization in 1936. Latimore attended the University of Pittsburgh and Thiel College, Greenville, Pennsylvania.

Hugh L. Ross and **Charles L. Babb** have been named assistant manager and chief engineer, respectively, of Allis-Chalmers Manufacturing Company's centrifugal pump department. Ross had been chief engineer of the centrifugal pump department since 1945. He came to Allis-Chalmers in 1928 after graduating summa cum laude in mechanical engineering from Yale University. Babb, who had been engineer-in-charge of centrifugal pump design, joined Allis-Chalmers in 1924 after receiving his mechanical engineering degree from Purdue University. His papers won prizes in the 1950 and 1954 Steel Founders' Society of America national awards contests.

Salt Water Disposal
handled by WISCONSIN-POWERED Deming Pumping Unit



The problem of getting rid of salt water after it has been separated from the oil, without polluting surrounding land, streams or endangering livestock, has been successfully solved with this heavy-duty pumping unit.

This specially designed pump, made of special materials, best suited to this type of operation, will handle 1200 barrels of oil field brine per day at 1,000 lbs. pressure, forcing the water back into the porous formation. This unit is being used by leading oil producers and is giving a very good account of itself, according to reports from the field.

A heavy-duty V-type 4-cylinder Wisconsin Air-Cooled Engine provides the steady-going, completely dependable power that keeps the pumping unit going day in and day out, with an absolute minimum of human attention and servicing. Tapered roller bearings at both ends of the crankshaft carry the load smoothly and provide fullest protection against bearing failure. Extremely efficient AIR-COOLING solves the cooling problem under all weather conditions, from sub-zero to 140° F.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

John Flanagan has been appointed resident manager of Johnston Testers, Ltd., of Calgary, Alberta, Canada. He will be in charge of Johnston operations in all of Canada. Flanagan moved to this assignment from a post with the Johnston company in Los Angeles, California. He joined Johnston Testers in 1942 in the Los Angeles district. In 1946 Flanagan was promoted to the export department, where he served as a service representative covering Mexico, South America and Europe.

John Flanagan

J. W. Shier

John W. Shier has been appointed assistant general manager of Acheson Colloids Company. Shier was the company's production manager, and **Bart C. Dickey,** formerly process development engineer, has been promoted to fill this position.

Shier, who joined Acheson Colloids as a plant engineer in 1949, attended the University of Michigan and was graduated as a chemical engineer from Wayne University. Dickey was graduated with a BS in mechanical engineering from Wayne University.

Griswold A. Price has been appointed assistant vice president of sales of the western area for the United States Steel Corporation. He succeeds **Herbert J. Watt,** who has retired after 43 years service as a sales executive in the steel industry. Price's entire business career has been with the United States Steel Corporation, having begun in 1919 as a student in the Gary Steel Works upon graduation from Northwestern University. He was named manager of the Chicago, Illinois, district office in 1947. **Glenn L. Martin** has been made plant manager of the Orange, Texas, plant of U. S. Steel's American Bridge division. A veteran of 20 years with U. S. Steel's Consolidated Western Steel division, Martin was general superintendent of the Consolidated Western plant at Orange from 1953 until its transfer August 1 to the American Bridge division.

Carl L. Zak has been appointed general sales manager of the newly formed Phoenix Steel Tube division of Phoenix Iron & Steel Company, subsidiary of Barium Steel Corporation. Zak formerly worked for Korhummel Steel and Aluminum Company, where he was general manager in charge of sales. Prior to that time, he was general manager of sales with Pittsburgh Steel Company and has held various sales positions in the Seamless Tube division of Youngstown Sheet & Tube Company.

Dr. Wyly M. Billing and **John R. L. Johnson Jr.,** members of the board of directors of Hercules Powder Company, have been elected vice presidents of the company. Both were elected members of the company's executive committee. Dr. Billing has been general manager of Hercules' synthetics department since 1943, and Johnson has been director of the company's legal department and general counsel since 1949. A former assistant director of Hercules central research laboratory near Wilmington, Dr. Billing was the founder of the company's synthetics department, beginning as manager in 1936 when it was about a one-man department. A graduate of Alabama Polytechnic Institute, he earned his master's degree at Columbia University and his doctorate at the University of Cincinnati. He joined Hercules in 1917 at Parlin, New Jersey, as an analytical chemist and was elected a director of the company in 1945. Johnson received both a BA and an MA degree in philosophy, from William and Mary College and the Harvard Law School. He worked as a junior attorney with the Securities and Exchange Commission before joining Hercules in 1936 as assistant general counsel of the legal department. **Mahlon G. Milliken** has retired as a vice president and member of the executive committee of Hercules but will remain as a member of the board of directors until the end of the year. He invented and perfected the Milliken Continuous Digester for the production of nitrocellulose, a basic ingredient of lacquers, and his invention, therefore, was vital to the automotive and many other industries that use lacquers and films in great quantities. Milliken was graduated as a civil engineer from Rutgers University. He joined Hercules in 1915 as a surveyor. In 1934, Milliken became general manager of the cellulose products department, was elected a director of the company in 1936 and vice president and member of the executive committee in 1945. **Henry A. Thouron** has been appointed general manager of the synthetics department, and **Charles S. Maddock** has been made director of the legal department and general counsel. Thouron, assistant general manager of synthetics since 1952, succeeds Dr. Billing. Maddock, assistant director of the legal department since 1951, has succeeded Johnson. A graduate of Princeton University, Thouron became associated with Hercules in 1934 as a member of the Naval Stores department sales staff in Wilmington, Delaware. Maddock received his bachelor's degree from the University of Colorado and his LLB degree from Harvard University law school. He joined Hercules as assistant general counsel in 1943.

Kenneth Lieber has been appointed assistant vice president in charge of sales of United States Steel's National Tube division. Lieber was graduated from the Thayer School of Engineering at Dartmouth College. He began his business career in 1937 in the engineering department of the Pennsylvania Railroad Company.

Edward C. Burdick, director of The Dow Chemical Company's patent department for the past 18 years and a specialist in chemical patents, has retired after nearly 40 years service with the company. **William M. Yates,** who has been assistant director since last February, has been named as his successor. Burdick will continue to serve the company, however, in his new capacity as a consultant. Active in Dow's pioneer work on magnesium, Burdick was a member of a four-man research and development team which in 1916 made the first pound of magnesium ingot produced by Dow. Yates has been associated with the patent department during his 20 year career with the company except for three years service with the organic semi-plant and magnesium laboratories. He holds both a BS and MS in chemical engineering from Washington University.

Ken S. Ramey has been named sales manager for the petroleum equipment division of Axelson Manufacturing Company, division of U. S. Industries, Inc. Ramey succeeds **J. R. Walker,** who continues with Axelson as a consultant on marketing and distribution problems. Ramey has been the Mid-Continent manager for Axelson in Tulsa, Oklahoma, since 1950. He joined the company in Coalinga, California, in 1923.

W. C. Robinson

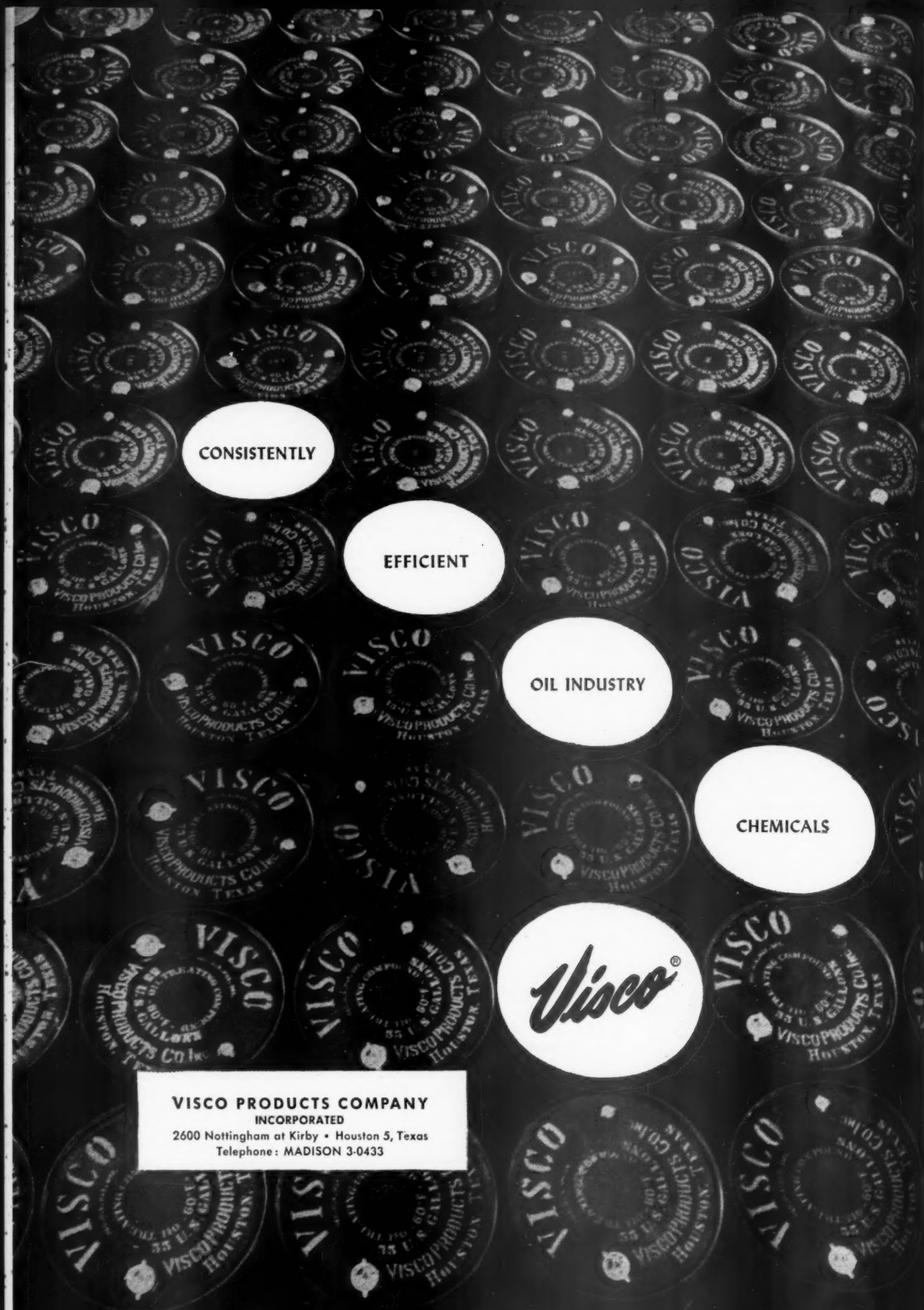
K. S. Ramey

W. C. (Bill) Robinson has been appointed an assistant sales manager of Tube Turns, a division of the National Cylinder Gas Company. Robinson received his BS in commerce at Ohio State University. He was associated with the Robert H. Clark Company before joining Tube Turns in 1944 as a sales representative in the company's Pittsburgh, Pennsylvania, office. **Frank Briggs** has been named to the staff of the company's sales development department. Briggs joined Tube Turns in 1942 and became a member of the plant's accounting and materials section. He was transferred to the sales department in 1947.

W. B. Caldwell has retired from the presidency of the Calumet Steel and Franklin Steel divisions of Borg-Warner Corporation. **Howard J. Davis** has been elected to succeed him. Caldwell had been president of the two divisions since 1951. He joined Calumet Steel in 1935 as works manager, became vice president and works manager of that division in 1937, and was named vice president and general manager of both Calumet Steel and Franklin Steel in 1947. Davis previously was assistant to the president of the Colorado Fuel and Iron Corporation, a company which he first joined in 1940. He also has served Colorado Fuel and Iron as manager of its Washington, D. C., office and as assistant general manager of sales for all of the corporation's products.

Frank L. Wilhelm has been elected assistant vice president of The Rust Engineering Company. Wilhelm joined the Rust organization in 1936 as a field office manager and later served as superintendent on a number of the company's major construction projects. His most recent field assignment was procurement manager for the company's large construction project at Oak Ridge, Tennessee.

Sam P. Stone has been appointed vice president of Avondale Marine Ways, Inc. Stone joined Avondale in 1945, and in his new capacity will be in charge of the engineering department. After receiving his Bachelor of Science degree from Rose Polytechnic Institute, he practiced architecture prior to joining Avondale.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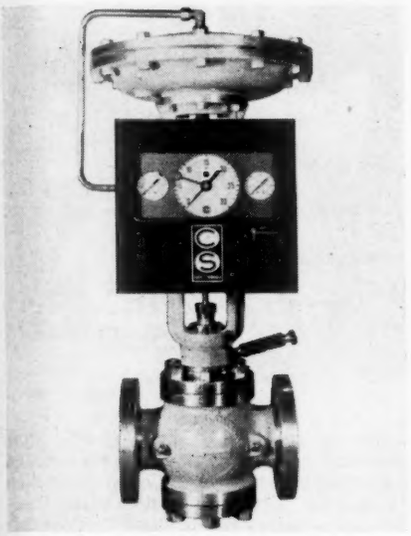
- services



Pressure and Temperature Pilot. Known as the Cash Standard Type 51, this pilot is claimed to be the first of its kind to permit regulation of temperature as well as pressure. The pilot is applicable for pressure ranges from 0-15 to 0-10,000 psi, and 0-30 in. H_2O and 0-30 in. Hg vacuum. Temperature ranges are from — 40 F to 1000 F, with mercury-actuated armored capillary temperature-sensing element.

A. W. Cash Company.

Circle number (1) on reply card.

Stationary Compressor Line. LeRoi Division announces a new line of 50, 75, and 100-hp stationary compressors that have displacements of 260, 415, and 550 cfm at 125 psi operating pressure. They are designed for applications where compactness, light weight, and a minimum of operator attention are required. Compressors have a balanced design that reduces vibration and noise to a minimum.

LeRoi Division, Westinghouse Air Brake Company.

Circle number (2) on reply card.

Low-Cost Swivel Joints. Chiksan has introduced two swivel joints in ½ in. and ¾ in. sizes. One is a permanent-clamp design, Junior Joint No. 1, for use on air, fuel, hydraulic, and other lines where free swiveling action is required. The other, Junior Joint No. 2, is a controlled torque design for use on coolant lines and other flexible lines that are required to lock into position.

Chiksan Company.

Circle number (3) on reply card.

Plastic Steel. Devcon, a combination of 80 per cent steel and 20 per cent plastic, is said to be as easy to handle as modeling clay. Two hours after the addition of a hardening agent, the mixture becomes a rigid, tough, strong, steel-like mass. No heat or pressure is required. Originally developed for making tools, jigs, fixtures, and molds, it is also being used for repair purposes.

Chemical Development Corporation.

Circle number (4) on reply card.

Diaphragm Motor Valve. Unit has a bolted-clamp type stem connection that allows stem adjustment of 50 per cent of total travel in either direction. It will not shake loose from vibration or rotational inner-valve forces, and it can be disconnected in the field without damage to the stem. The topwork may be removed without disturbing the stuffing box.

Fisher Governor Company.

Circle number (5) on reply card.

Packaged Fluid Agitators. Philadelphia Gear Works announces a new line of packaged Fluid Agitators. With the packaged agitator, a complete Fluid Agitator Service is provided. The company's engineers are prepared to specify agitation to meet full process requirements.

Philadelphia Gear Works.

Circle number (6) on reply card.

Weather-Proof Outdoor Floodlight. This weather-tight, rust and corrosion-proof, outdoor floodlight is designed to eliminate back-light halo completely and permit maximum circulation of cooling air. Cast aluminum housing is mounted on an adjustable swivel arm that locks in position with inter-gripping teeth that cannot be loosened by vibration, shock, or pole sway.

Stonco Electric Products Company.

Circle number (7) on reply card.

Softener Controls. An automatic control system for dual-tank zeolite softeners has been developed by Graver Water Conditioning. System includes electrical control panel, flow meter, automatic multi-port valve, zeolite softeners, brine measuring tanks, and connecting lines. Outstanding feature of system is an electrical control panel containing a series of relays and a multiple-cam timer that initiate periodic, timed regeneration of the softeners.

Graver Water Conditioning Company.

Circle number (8) on reply card.

Sprayweld Hard-Facing. A series of Colmonoy alloy powders that produces improved deposit efficiency when used in spraywelded hard-facing applications is now available. Improved hard-facing powders are available as Colmonoy No. 4, 5, and 6. Colmonoy No. 4 produces Rockwell hardness of 35 to 40 on C scale, while No. 5 and 6 produce hardness ranges of 45 to 50 and 56 to 61 respectively.

Wall Colmonoy Corporation.

Circle number (9) on reply card.

Electrically Conductive Lubricant. Conducto-Lube is a highly conductive top-grade lubricant designed for use in conducting hinge-joint switches. It is claimed to be ideal for high-speed air blast breakers where a lubricant is essential.

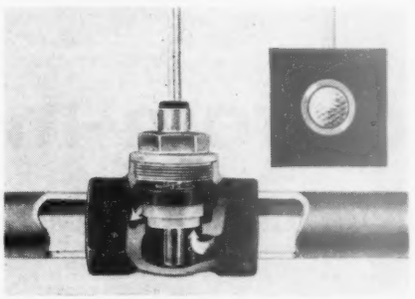
The Conducto-Lube Company.

Circle number (10) on reply card.

Electric Timer. Unit provides a cycle range from a fraction of a second to 28 days. Timer is driven by a constant speed, synchronous electric motor through an all gear drive. Changes in cycle are made by moving "pick-up" gear in timer to the desired speed.

Gorrell and Gorrell Company.

Circle number (11) on reply card.



Flow Indicator. Model FI-200 Flow Indicator is designed to indicate flow (or lack of flow) of a liquid through a pipe line. The manufacturer states that this instrument is unusually compact, simple, and easy to install. Flow through the unit actuates a switch that can be used to operate a pilot light, horn, or other warning signal. It is available in ¼ in. to 3 in. sizes.

The Gems Company.

Circle number (12) on reply card.

IN DRILLING AND PRODUCING . . .

Slush Pump Valve. Mission Manufacturing has added the Mud Monarch Slush Pump Valve to its line of fluid end slush pump parts. The valve is specifically designed for high-pressure jet drilling. The rubber seal ring of the Mud Monarch is on the seat and is designed so that its function is not affected by wear of the valve and seat.

Mission Manufacturing Company.

Circle number (13) on reply card.

Pressure Relief Valve Signal. Kinzbach Relief Signal consists of pilot valve actuated by movement of relief valve connected between an air supply and an air horn. At first sign of opening movement of relief valve piston, relief valve admits air to blow horn continuously until relief valve piston returns to closed position.

Kinzbach Tool Company, Inc.

Circle number (14) on reply card.

XUM

you get custom-made results

with factory-made hangers and eliminators

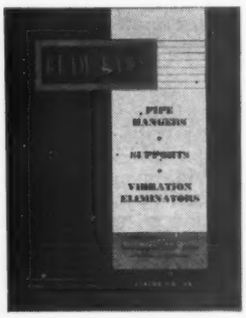
Each is a complete packaged unit, designed to serve a particular purpose.

So when you use our functional spring hangers . . . which have the Blaw-Knox patented *internal swivel action* . . . and our constant support spring hangers and vibration eliminators, you get custom-made results. And that holds good for rigid hanger assemblies and overhead roller assemblies.

Proper selection cuts your engineering time and expense . . . yet enables you to meet the most exacting standards. Each is ready to install, so you eliminate expensive cutting, threading and assembling in the field.

Our engineers, who have solved many tough hanger and piping vibration problems, are always available to both design and make recommendations for your hanger requirements.

BLAW-KNOX COMPANY, *Power Piping and Sprinkler Division, Pittsburgh 33, Pa.*



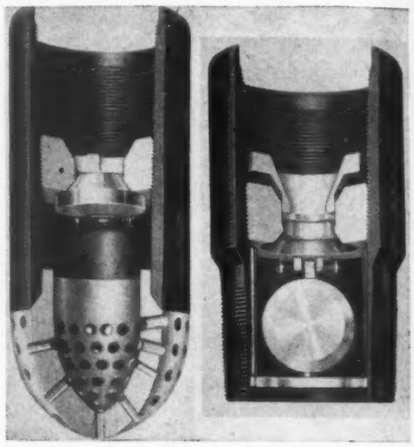
For more information on our complete line, write for your copy of Bulletin No. 54.

BLAW-KNOX **PIPE HANGERS**

Complete line of functional spring hangers • constant support spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated piping systems for all pressures and temperatures

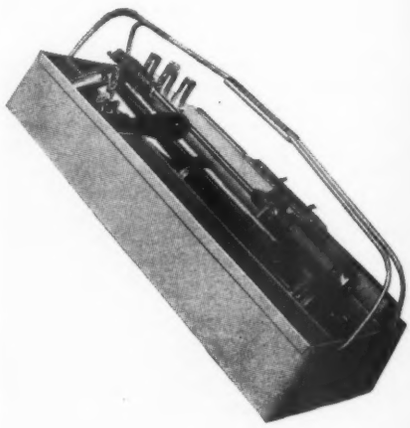
New Equipment

Orifice Fill Shoe and Collar. Baffle in the Fill Shoe has a spring-loaded flapper valve with orifice choke that controls rate of fill. Orifice inserts are available in various choke sizes, engineered to meet all pipe requirements. The Fill Collar also has an aluminum baffle, spring-loaded flapper valve, and shear pin assembly for holding valve open until tripped by application of pressure. Type "O" Fill Shoe and Collar are placed in the pipe in the same position as conventional cementing equipment. Type "O" Fill Collar functions as a back-pressure valve or float collar. Seating of the cement plug on the fill collar releases the flapper valve, which then functions as a back-pressure valve to assure position flow-back control. It can be converted to an effective float collar at any point by a trip ball dropped into the casing, which closes the flapper valve in the collar.



Rector Well Equipment Company, Inc.

Circle number (15) on reply card.

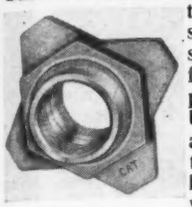


Gauger's Equipment Case. Walker Gauger's Equipment Case is made entirely of spark-proof, rust-proof, and light-weight aluminum. Tray is better balanced because of twin bails for carrying. Weight has been reduced more than 50 per cent; weighs less than four pounds. Handles lay out to the side giving the gauger free and clear access to his equipment. Compartments are provided for each piece of equipment. Carrying bails and tray dividers are removable for easy cleaning.

W. L. Walker Company.

Circle number (16) on reply card.

Four-Star, Hammer-Type Lug Nut Union. Product is being made in 2-in. to 4-in. sizes, inclusive, and features speedy make or break for "hard-to-get-at-places." The "4-Star Union" incorporates an exclusive combination of both lug and hexagonal-shaped nuts with regular or Double-Start Acme threads, for fast make or break with either a hammer or wrench.



Catawissa Valve & Fittings Company.

Circle number (19) on reply card.

Airborne-Carborne Scintillation Counter. Mt. Sopris Instrument announces the Airborne-Carborne Scintillation Counter Model SC188DA. This exploration instrument in designed for light plane or helicopter installations.

Mt. Sopris Instrument Corporation.

Circle number (20) on reply card.

No-Glo Thread Lubricant. Lubricant is a new thread dope that contains No-Glo, a specially refined oil that will not fluoresce under the ultra-violet light. It is designed for use when drilling exploratory wells because it does not contaminate the drilling mud with fluorescent materials that make geological analysis of cores and cuttings difficult. Lubricant is manufactured from a modified API formula and contains powdered copper, lead, zinc, graphite, and molybdenum disulfide suspended in a heat resistant Bentone base.

Oil Base, Inc.

Circle number (21) on reply card.

Pressure Control Regulator. A regulator called Type IL-2 (2-in. pipe size), is announced by Acme Regulator Company, for inlet pressure up to 1500 psi and from 10 to 600 psi outlet pressures. It is "in-line" regulator designed for use anywhere in the field where pressure reduction is necessary. The stainless steel ball valve used is free to revolve or rotate. Due to the simplicity of design and a minimum of working parts, it features quick, easy repairs; just unscrew the bottom hex plug, no need to remove regulator from the line.

Acme Regulator Company, Inc.

Circle number (22) on reply card.

Fluidrill Stops Rig Vibration. Directo's 12¼-in. Fluidrill reduces rig vibrations to a minimum while drilling the intermediate hole. Fluidrill enters the string like a drill collar, subbing directly to the bit. Utilizing the mud pressure and a 2½ ft stroke telescoping barrel, the Fluidrill maintains a constant pressure on the bit.

Directo Corporation.

Circle number (23) on reply card.

Rod Jar-Back-off Tool. Newly introduced is the Hooks Pump Tool, which is inserted in the rod string to assist in pulling stuck pumps. Should pump stick, jars are activated by shearing pin in tool. If jarring fails to unseat pump, tool is provided with back-off thread to release rod string.

Hooks Machine Works.

Circle number (24) on reply card.

IN REFINING . . .

Powerful Hydrocrane. Jobs for a light, high-speed truck crane can now be handled by the all-hydraulic H-5 Hydrocrane, developed by Bucyrus-Erie Company. Extremely maneuverable and mobile, the H-5 can be used profitably for high lift, close-quarter erection, heavy bucket or crane work, big lift, indoor jobs, and precision materials handling assignments. It is available as a ½ cu yd excavator and as a 9-ton lifting crane.

Bucyrus-Erie Company.

Circle number (25) on reply card.

Heat Exchanger Quick-Opening Door. A self-seating, quick-opening door, developed by The Patterson-Kelley Company, reduces the time to open heat exchangers, autoclaves, sterilizers, and other pressure vessels. Lever-Lock Door is locked and unlocked by means of bars. Capable of withstanding temperatures from —70 F to 400 F, and pressures ranging from full vacuum to 300 psi, it is used where frequent entry, cleaning, or inspection is required.

The Patterson-Kelley Company, Inc.

Circle number (26) on reply card.

Direct Reading Flow Rate Meter. Revere Model F-8110 provides visual flow rate indication in circulating, lubricating, and fueling systems. The one and a half-pound unit is designed to cover a flow range of 7 to 70 gph and to operate at temperatures of —65 F to 160 F.

Revere Corporation of America.

Circle number (27) on reply card.

Glassed-Steel Tank Trailer. This safety-engineered tank trailer of glassed steel construction permits delivery of a wide variety of corrosive liquids. Designed and fabricated by Pfaudler, the 2200-gal unit handles all acids, except hydrofluoric, and alkalies to pH 12.

The Pfaudler Company.

Circle number (28) on reply card.

Temperature Probe. Temperatures may be measured with this probe anywhere in operation of the system. Series 8000 Probe a hydraulic network without disturbing is placed around the hydraulic line, and the split cylinder casting thermally isolates that section of the line while temperature-sentitive element is brought to bear against the line wall.

The Arnoux Corporation.

Circle number (29) on reply card.

Galvanizing Repair. Metal alloy stick ReGalv is now available for regalvanizing any area where the zinc coating (of galvanized sheets, shapes, fittings, etc.) has been damaged or destroyed by welding, flamecutting, bending, or the like. It melts and bonds at temperatures as low as 600 F. No flux or other pretreatment is required other than knocking or brushing off loose scale.

Rotometals.

Circle number (30) on reply card.

Micro-Distillation. Distillograph, designed to meet the need for rapid, accurate separation of volatile compounds, is being marketed by Research Equipment. Mixtures of volatile samples, formerly impossible to separate, may now be completely resolved without the formation of azeotropes. Fractions boiling as low as 20 C may be quantitatively collected.

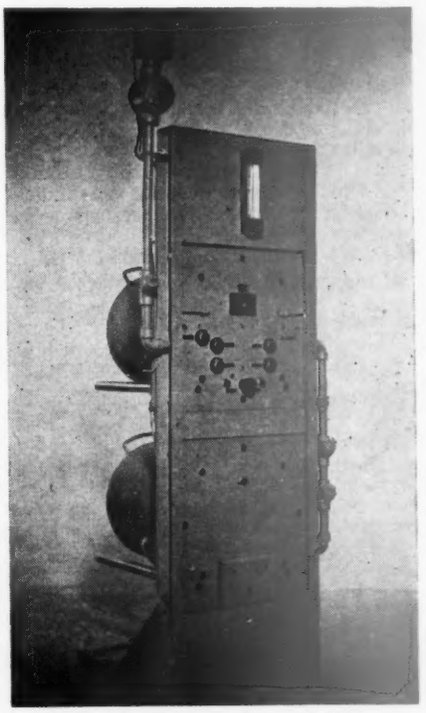
Research Equipment Corporation.

Circle number (31) on reply card.

Infrared Analyzer. Consolidated-Phillips Automatic Infrared Analyzer, one of four plant-control instruments developed and pilot-produced by Phillips Petroleum Company, is being manufactured by Consolidated. The infrared analyzer provides continuous analysis of specific components in gas streams necessary to production of petroleum products.

Consolidated Engineering Corporation.

Circle number (32) on reply card.



New Equipment

Reversing Transmission. A reversing transmission for use on Ford tractors has been introduced by Sherman Products. By providing for five forward and five reverse speeds, the unit enables fast shuttle operations of the tractor for maneuvering into position or working with front-end equipment.

Sherman Products, Inc.

Circle number (33) on reply card.

Water-Driven Motor for Tube Cleaner. Airetool Manufacturing has introduced a water-driven, ball-bearing tube cleaner motor as a companion to its complete line of air and steam-driven motors. Motor is expected to find application in plants where air or steam is not available for operating tube cleaning equipment.

The Airetool Manufacturing Company.

Circle number (34) on reply card.

Low-Cost Valve. A low-cost, quick-acting valve for use on petroleum tank trucks and similar equipment has been announced by Betts Machine. Known as the Warren Ecliptic Valve, the body is of fabricated steel construction with stainless steel stem, brass disc, and trim. The seat is of composition material. Unit weighs only 7½ lb in the 3-in. size. Manufacturer reports that the steel construction contributes to greater safety in case of accident or fire.

Betts Machine Company.

Circle number (35) on reply card.

Centrifugal Counter-Current Solvent Extractor. Unit is designed to process 500 gpm in chemical extraction systems having difficult mixing and separating characteristics. Chemizon extractors are presently in use in furfural and phenol extraction of oils, extraction of aromatics, and treating crude oils.

Podbielniak, Inc.

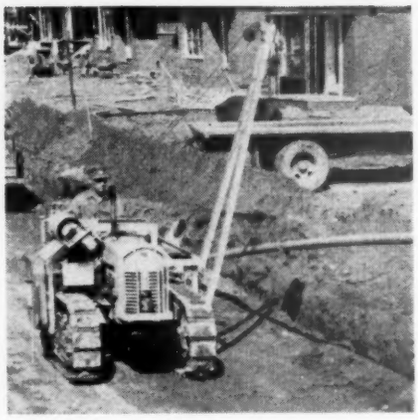
Circle number (36) on reply card.

IN PIPELINING . . .

Excavator-Bulldozer Attachments. Pippin Construction Equipment has introduced a Pippin Excavator and Angling Bulldozer for mounting on the International 300 Utility tractor. Excavator digs to a depth of over 10 ft and loads truck to a height of 9 ft with back-hoe bucket and 12 ft with shovel bucket. The front drive pump can be used for operation of both the excavator and front-end attachments.

Pippin Construction Equipment, Inc.

Circle number (37) on reply card.



Side Boom for Crawler. A handy and versatile side boom is now being offered for the Oliver OC-3 Crawler. Nicknamed the "Little Boomer," the unit is designed specifically to answer the need for a small, maneuverable big-capacity unit crawler-boom for light pipe line handling work. It lifts loads of up to 1600 lb, will lay and lower-in up to 6-in. line, and will carry single 40 ft lengths up to 12 in. "Little Boomer" can be equipped with automatic hydraulically operated counterbalance.

The Oliver Corporation.

Circle number (38) on reply card.

Flat-Type Welding Ring. Welding ring with ⅛-in. diameter spacer pins has been introduced by Tube Turns. It was developed to improve the submerged arc welding of pipe and fiittings, but is also suitable for many manual welding applications. Small spacer pins automatically center ring in the joint. Projecting beyond the pipe OD they prevent the ring from shifting up or down stream. After pipe ends are tacked together, the spacer pins are knocked off with the chipping hammer.

Tube Turns Division of the National Cylinder Gas Company.

Circle number (39) on reply card.

Multi-Channel Mobile Radio Station. Completely self-contained transmission, reception, and termination facilities have been designed by Du Mont engineers, they are available to meet the most exacting communications needs. Unit, designated as Du Mont Type MCA-351-A Base Station, is designed to fill the requirements of a base station for two-way frequency-modulated communications at any pre-selected frequency in the 144-174 MC band.

Allen B. DuMont Laboratories, Inc.

Circle number (40) on reply card.

Pipe Line Marker Vent. L&M has a combination marker and vent, which is a one-piece aluminum alloy casting with a 7-in. by 12-in. message panel and screened vents. The message is cast in raised letters and can be painted in any color combination desired. The vent openings are screened with a heavy, rustproof, perforated metal screen to keep out insects. Marker-Vent Collar slips down over the top of the pipe and two Allen screws are tightened to hold it firmly in place.

The L&M Company.

Circle number (41) on reply card.

Combination Pipe Dolly. Rollers permit rotating for either manual or automatic welding. Dolly is used for leveling and rolling and can be used to align pipe. It handles all pipe sizes through 36-in. and is ruggedly constructed to handle a load capacity of 2500 lb.

The H&M Pipe Beveling Machine Company.

Circle number (42) on reply card.

Intercommunications System. An intercommunication system providing two-way "private" conversation between stations without the use of any controls at either station during conversation, has been introduced by Talk-A-Phone. System is operated automatically by voice, eliminating the necessity of manipulating any controls during the conversation. It is available in 10 and 20-station capacity.

Talk-A-Phone Company.

Circle number (43) on reply card.

Single-Wrap Tape. Development of a single-wrap coal tar tape for pipe, joints, fittings, and couplings has been announced by Tapecoat. Known as "Tapecoat-X," it permits single-wrapping with only ½ in. overlap, in contrast to the regular method of overlapping more than half the width of the tape to secure effective protection.

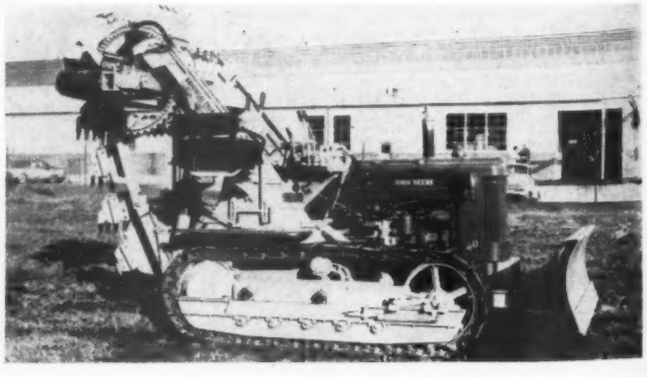
The Tapecoat Company.

Circle number (44) on reply card.

Utility Trencher. Universal Trencher is now approved allied equipment for mounting on the John Deere 40 Crawler Tractor. Machine has a digging depth of 4 ft and trenches 14, 16 and 18-in. widths. Designed as a utility trencher, it holds line and grade without effort, is hydraulically controlled, and trenches easily in small space. The Universal Trencher switches dirt instantly to either side and employs a heavy-duty backfiller blade to replace dirt.

Heller Manufacturing Corporation.

Circle number (45) on reply card.



NEW oil and gas Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

- brochures
- bulletins
- catalogs

Automatic Valve Positioner. A bulletin describing the Wheelco Throttltrol, an automatic valve positioner for use in conjunction with any control instrument having a "high" and "low" contact with a neutral position.

The Wheelco Throttltrol automatically and accurately corrects for variations in heat requirements due to changes in furnace load, control settings, air and fuel pressure, BTU values, or combustion efficiency in batch type operations. The unit is completely self-adjusting and requires no manual adjustments or resetting devices.

Wheelco Instruments Division, Barber-Colman Company.

Circle number (46) on reply card.

Automatic Welding Equipment. Air Reduction Sales has announced availability of a 16-page catalog featuring Aircomatic (Airco's inert-gas-shielded metal arc welding process) welding equipment. Manual and automatic units along with accessory apparatus and welding wire are included in the illustrated booklet.

Air Reduction Sales Company.

Circle number (47) on reply card.

Program Control. A bulletin of Minneapolis-Honeywell, "Program Control of Process Variables," describes the methods and advantages of employing automatic, time-conditions control for many industrial processes and tests. A convenient "selection chart" aids in choosing the right instrument for any program control application.

Minneapolis-Honeywell Regulator Company.

Circle number (48) on reply card.

Centrifugal Tachometers. A 4-page, illustrated folder describing the simplified operation and ease of installation of its new Stationary Centrifugal Tachometers has been released by the manufacturer, Boulin Instrument. The folder explains and illustrates how the design components of the tachometer are easily adaptable for quick installation on any type of plant operating equipment, such as motors, conveyors, machines, turbines, shafting, and specialized equipment, to check and show proper speeds for maintaining optimum performance.

Boulin Instrument Corporation.

Circle number (49) on reply card.

Ultrasonic Thickness Gage. A new four-page folder on the "Vidigage," ultrasonic-resonance thickness gage, has been released by Branson. The "Vidigage" measures thickness instantaneously from one side of the material under test. Thickness is read from the location of a bright vertical line on a 21-in. television tube. A wide choice of direct reading scales is available for thicknesses between 0.005-in. and 2.5-in., with accuracies as high as 1/20%. Large structures and remote locations may be tested by using extension cables, up to 1000 ft long, between the gage and the small oscillator.

Branson Instruments, Inc.

Circle number (50) on reply card.

Hollow Shaft Motors. A bulletin in full color introducing its latest line of vertical, hollow-shaft pump motors has been published by ACEC Electric. The motors described and pictured in the publication have been developed especially for driving heavy-duty turbine pumps used in agriculture and industry. The booklet explains features of design and construction that enable these motors to operate day after day without supervision, in exposed locations, where maintenance is difficult and downtime costly.

The ACEC Electric Corporation.

Circle number (51) on reply card.

Propeller Fans. Two new models, a By-Pass Duct Fan and a Double-Ring Reversible Fan, are included in a 40-page, illustrated propeller fan catalog published by Hartzell. In addition to the information on the two new fans, sepcifications, dimensions, and performance figures are given on eighteen other types of industrial ventilating fans plus intake units, unit heaters and accessories.

The Hartzell Propeller Fan Company.

Circle number (52) on reply card.

Packaged Compressor. A 124-hp, electric-driven air compressor has been added to the Ingersoll-Rand line of air-cooled, two -stage Type 40 stationary compressors. This new unit is described in a 4-page bulletin. The new size is expected to fulfill the need of contractors and industries for a lightweight compressor that can easily be moved from job to job.

Ingersoll-Rand Company.

Circle number (53) on reply card.

Liquid Meters. A catalog of Niagara Industrial Liquid Meters is just off the press. It covers the simple single-piston line of Niagara Meters for volumetric measurement of practically all liquids. This catalog also features the new Exposition-Proof Electricontact Registers, the latest refinements in chemical meters, as well as complete information on standard lines of Niagara Meters for non-corrosive liquids.

Buffalo Meter Company.

Circle number (54) on reply card.

Chemical Sealant. A reference guide and chart explaining the multiple uses of special chemical sealants in a variety of industrial, manufacturing, processing, agricultural, and maintenance operations has been published by the industrial division of Permatex. This guide describes the proper sealants for use in hundreds of industrial applications, including plumbing and heating, exposed and underground pipe lines and tanks, and all mechanical and industrial equipment requiring leak-proof air, water and vapor and chemical connections. Also included are descriptions of sealants exceptionally resistant to vibration, resistant to hot and cold acids, alkali and salt solutions and to coolant chemicals.

Permatex Company, Inc.

Circle Number (55) on reply card.

Plunger Pumps. An illustrated bulletin on Vertical Triplex Single-Acting Plunger Pumps with 2, 4, 5 and 6-in strokes has been issued on plunger pumps with capacities up to 225 gpm and pressures up to 11,700 psi.

Worthington Corporation.

Circle number (56) on reply card.

Electronic Pressure Gage. A 4-page brochure on the BJ Vibrotron has been released by the electronic division of Byron Jackson. Vibratron Pressure Gages for the measurement of both static and dynamic pressure are described in the brochure.

Byron Jackson Company.

Circle number (57) on reply card.

Industrial Instrumentation. Entitled "General Catalog of Foxboro Industrial Instrumentation," a 126-page bulletin describes the latest recorders, controllers, and other units designed for industry applications. Design and engineering data are presented to assist in integrating Foxboro equipment into the system.

Foxboro Company.

Circle number (58) on reply card.

Industrial pH Guide. Users of industrial pH instrumentation may find it much simpler to match components such as meters, flow or immersion assemblies, electrodes, and manual or automatic electrode switches with the new Industrial pH Buyer's Guide now available from Beckman Instruments. The four-page illustrated bulletin shows pictorially which components replace older units and how older and newer components can be used together.

Beckman division, Beckman Instruments, Inc.

Circle number (59) on reply card.

Trade Literature

Primary Water Supply Pumps. Vertical turbine pumps for industrial and municipal primary water supply are described in an 8-page folder by Layne & Bowler. Included is a condensed selection table, a guide to horsepower and head-capacity ratings of Verti-Line Pumps.
Layne & Bowler Pump Company.
Circle number (60) on reply card.

Protecting Tubes and Wells. A four-page bulletin on Gordon Serv-Rite standard thermocouple protecting tubes and protecting wells has been printed. This bulletin is the largest single grouping of protecting tubes of various types and materials, according to the manufacturer.
Claud S. Gordon Company.
Circle number (61) on reply card.

Fire Extinguishing Agent. A 36-page page booklet has been published that gives detailed information on all types of Foamite Airfoam Equipment which is used as a fire extinguishing agent.
American La France Corporation.
Circle number (62) on reply card.

Atomizing Deaerator. A publication describing the requirements and principles of deaeration by atomization has been issued by Cochrane. One of the illustrations is a sectioned drawing in color showing water and steam flow during operation of the Cochrane Atomizing Deaerating Heater.
Cochrane Corporation.
Circle number (63) on reply card.

Offshore Drilling Equipment. In order to "package" its many products that are being used in the offshore drilling field, new literature has been published by Harnischfeger devoted exclusively to this line. An eight-page, accordion-type folder, it includes information and specifications on P&H revolving cranes, arc welders, welding electrodes, electric and chain hoists, and the complete line of P&H diesel engines. A feature that makes the bulletin especially useful is a series of charts that tell at a glance exactly which model crane in the complete P&H line best suits particular offshore requirements.
Harnischfeger Corporation.
Circle number (64) on reply card.

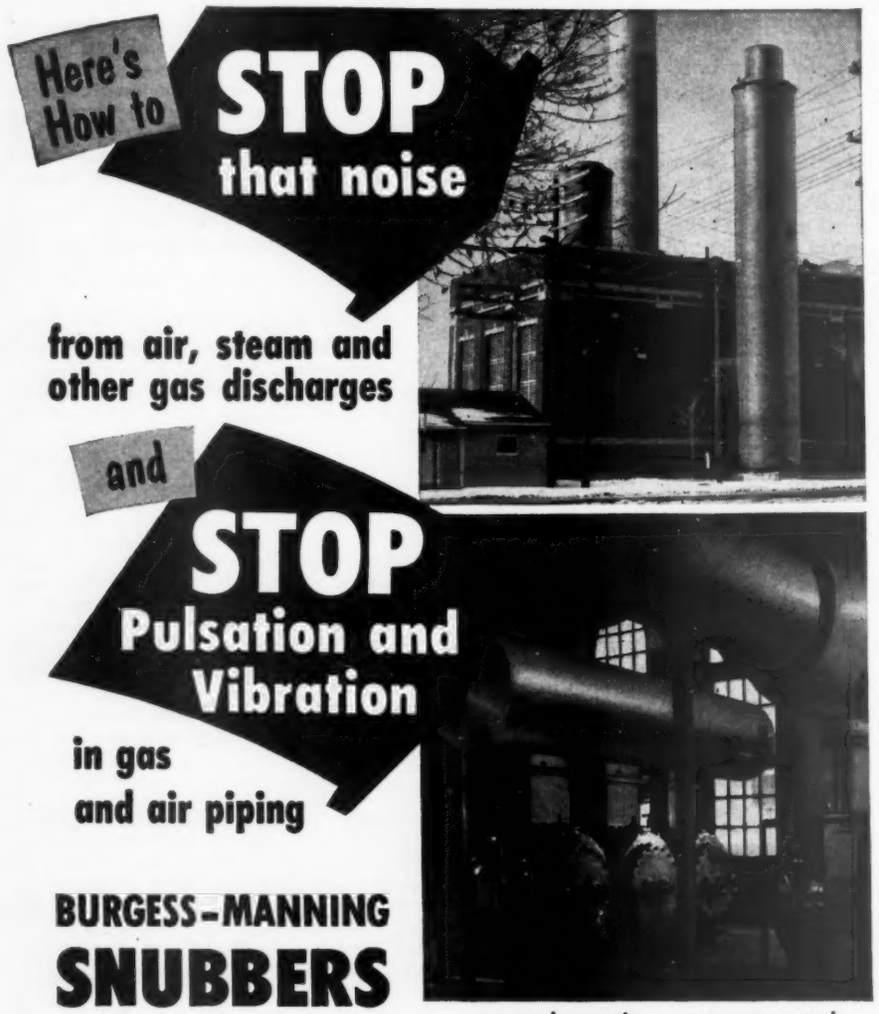
Control Valve Line. A brochure covering a new line of Honeywell diaphragm control valves, designated Series 400 has been issued. Data include actuator and body specifications, flow characteristics, and complete dimensions for the double-seated, single-seated, and three-way types that comprise the new line.
Minneapolis-Honeywell Regulator Company.
Circle number (65) on reply card.

Pneumatic Pilot Valve. Builders-Providence, Inc., has issued a six-page supplementary bulletin on flow and pressure control in water filtration and waste treatment plants and in many industrial processes. Control is maintained with a pneumatically actuated device weighing only 15 lbs and that is 16 in. by 36 in. long. Known as the BalanCel Pneumatic Pilot Valve Control Unit, this instrument comprises four basic sub-assemblies.
Builders-Providence, Inc., division of B-I-F Industries, Inc.
Circle number (66) on reply card.

Temperature Instruments. The complete line of Fischer & Porter filled thermal systems for indicating, recording, controlling, transmitting, compensating, and programming temperatures from —400 to 1000 F is illustrated and described in a catalog published by the company.
Fischer & Porter Company.
Circle number (67) on reply card.

Regulator Controls. Versatility and flexibility of its line of high and low-pressure balanced valve regulators are outlined in a 36-page bulletin, "Special Controls," published by Rockwell. Consideration of specific regulator problems and solutions are clearly presented by use of full pages of text together with a facing page of cross-sectional schematic drawings to each of 16 distinct gas regulation situations in which "special" controls are called for.
Rockwell Manufacturing Company.
Circle number (68) on reply card.

Pressure Relief Valves. A new Relief Valve Catalog Supplement covering four new models has been released by Patrol Valve.
The Patrol Valve Company.
Circle number (69) on reply card


Here's How to
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that noise
from air, steam and other gas discharges
and
STOP
Pulsation and Vibration
in gas and air piping
BURGESS-MANNING
SNUBBERS
— are engineered to effectively correct your specific noise or pulsation problem.
They are available in many different basic types for arresting intake and exhaust noises, some of which may integrally incorporate such additional features as air cleaning — or heat recovery — or spark arresting — or surge control — or water separating.
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- full makeup, easy breakout
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Trade Literature

Infrared Gas Analyzer. Latest information on the L&N industrial plant-type Infrared Gas Analyzer is now available in data sheet form. This sheet provides brief facts about installation, operation, and maintenance of the equipment.
Leeds & Northrup Company.
Circle number (70) on reply card.

Pre-Lubricated Bearing. Reliance Electric and Engineering has a bulletin entitled "New Automatic Grease Monkey," describing the unique Reliance Metermatic pre-lubricated bearing design. Used on the company's a-c. and d-c. motors, the bearing design features a metering plate that automatically regulates grease flow to the bearing and provides pressure relief against over-greasing.
Reliance Electric and Engineering Company.
Circle number (71) on reply card.

Diesel-Electric Generators. Compact and versatile, the line of small size, high capacity Caterpillar Diesel Electric Sets is described in "Modern Electric Power," published by Caterpillar Tractor. In four illustrated pages, this booklet describes the advantages of these sets, matched to their Cat Engines to provide maximum efficiency.
Caterpillar Tractor Company.
Circle number (72) on reply card.

Voltage Regulators. A catalog giving information on its complete line of voltage regulators has been printed by Raytheon. Its voltage regulators are claimed to be superior to any other static-type regulators in these important respects: Regulation between 95 and 130 volts of ±½ per cent, three times more accurate no-load to full-load regulation, 17 per cent less voltage change with frequency variation, and 28 per cent closer regulation with temperature changes. This applies to equipment subject to voltage variations, such as microwave links.
Raytheon Manufacturing Company.
Circle number (73) on reply card.

Electron Miscroscopes. An 8-page booklet titled "Questions and Answers on Electron Miscroscopes" is available from Research and Control Instruments division, North American Philips Company. Text material was prepared specifically to answer questions that are frequently raised in the field concerning operation and application of these instruments.
North American Philips Company, Inc.
Circle number (74) on reply card

Stainless Tubing & Pipe. Information of interest and value to engineers and designers associated with the use of stainless tubing and pipe is included in a data folder recently published by the Tubular Products Division of Babcock & Wilcox. Included are tables of analyses, mechanical properties, creep strength, physical properties, and oxidation resistance of nine of the most popular stainless tubing steels.
The Babcock & Wilcox Company.
Circle number (75) on reply card.

HERE'S HOW

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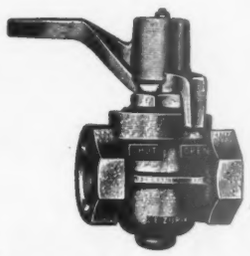
It takes only a short, easy QUARTER-TURN to open any DeZurik Easy-Operating Plug Valve WIDE OPEN or close it ABSOLUTELY SHUT! DeZurik's exclusive Eccentric Action provides the smoothest, simplest, surest operation of any plug valve.

The unique DeZurik Plug is rubber-faced on a rigid metal core. This plug delivers a conforming closure against the metal seat, closes 100% drip-tight even with solids intervening, won't ever distort, needs no reseating, no maintenance.



DeZURIK VALVES will excel in a whole range of petroleum process applications: on gasoline and diesel fuel loading racks, lube grease lines, mud lines, refinery gases and bleeder lines to butane and propane kilns.

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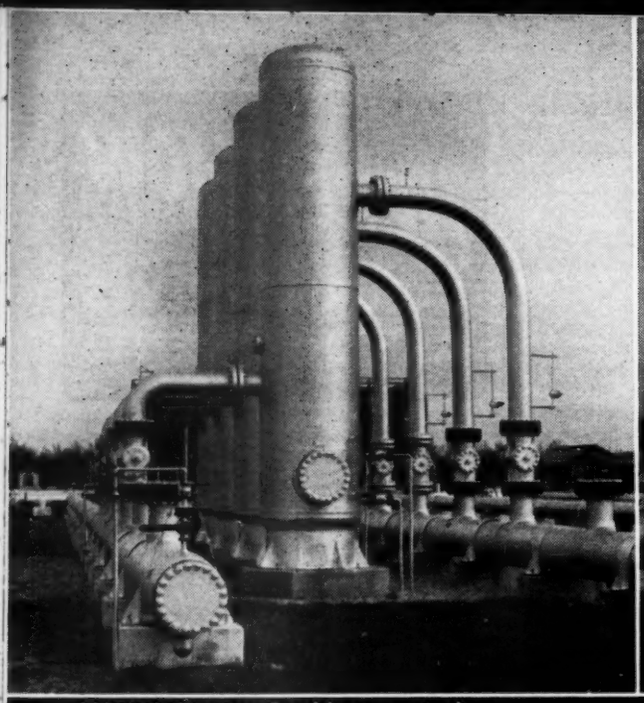
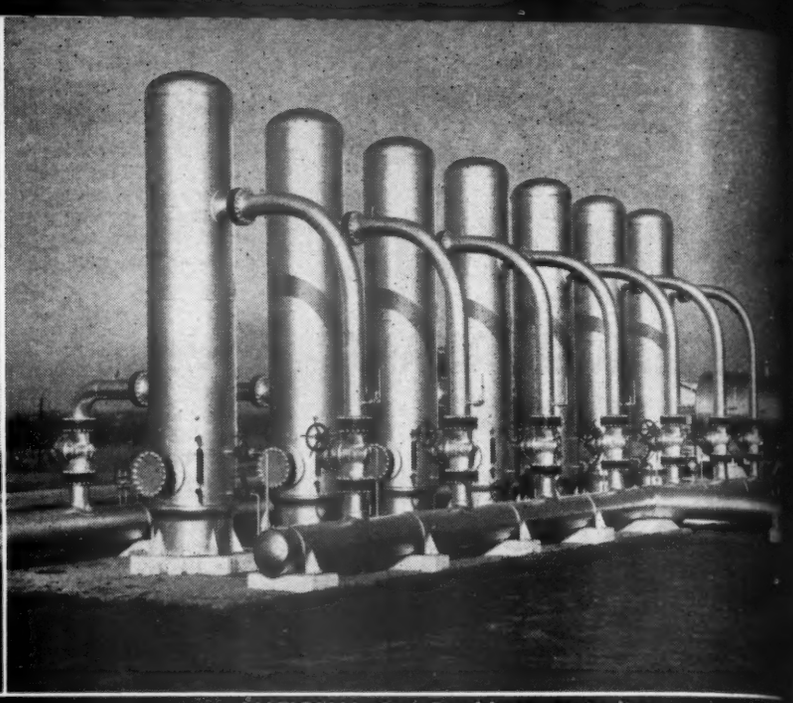
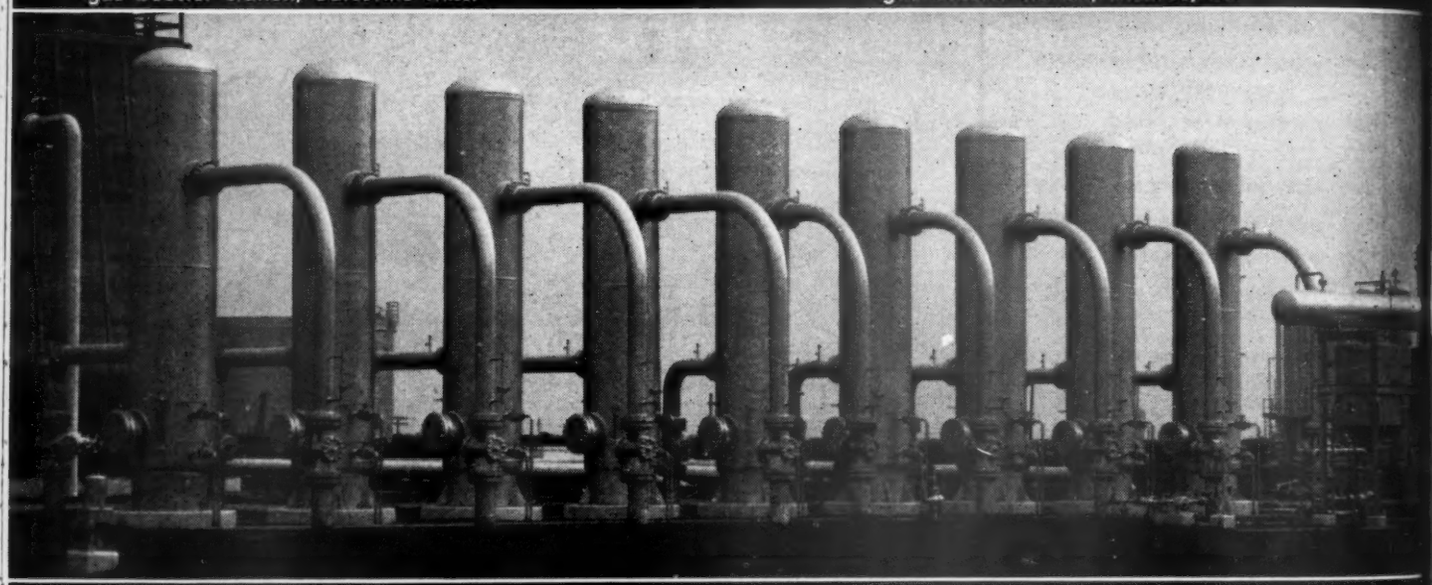


NATIONAL Gas Scrubbers, main line gas booster station, Batesville Miss.



NATIONAL Gas Scrubbers, main line gas booster station, Monroe, La.



NATIONAL Gas Scrubbers, main line gas booster station, Banquitte, Texas

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DI-HARD METAL – an "Oilwell"-Neilsen exclusive—is extremely hard and most resistant to abrasion. It has an exceptionally low coefficient of friction and is highly resistant to all types of corrosion.

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THE Petroleum ENGINEER

Four editions published monthly by The Petroleum Engineer Publishing Company, 800 Davis Building, 1309 Main Street, P. O. Box 1589, Dallas 21, Texas.

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Indexed by Industrial Arts Index and The Engineering Index, Inc.
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LETTERS

Rig Locator Response

The Drilling Rig Locator arrived the other day, and we think this is one of the finest things we have seen as far as drilling location is concerned. We wish to compliment you and your magazine very highly for this information. If this is going to be a permanent issue, please put us on your mailing or subscription list.

I would like to suggest one other thing that would be of great help to the rock bit industry. This would be a report issued three times a year covering the total quantity of rock bits used in a definite area. I realize that this is asking quite a lot, but as you know, the sources that are available for this type of information are very few and far between. Of course, we make our own survey of rig and rock bit usage in the areas we cover, but we would like to have more general information if possible.

A. S. Marshall.
General Sales Manager
H. C. Smith Oil Tool Company
Compton, California

I wish to thank you for your letter of August 30 to which you attached a copy of your Drilling Rig Locator.

We think this booklet is an excellent idea and would certainly subscribe to getting four of these in the event you should decide to make this a permanent part of your business.

L. O. Sahlen.
General Manager
Waukesha Engine & Equipment Company
Denver, Colorado

This is the first time I have ever seen a concise use made of rig locations. It will help anyone in the contracting or producing business . . .

Leland E. Brack.
Brack Drilling Company, Inc.
Fort Collins, Colorado

The Drilling Rig Locator is one of the finest directory ideas that has come out in years. It should be of priceless value to both operator and contractor and I know we will use it extensively . . .

E. A. Carter.
Vice President
Ray Smith Drilling Company
Dallas, Texas

Editor's Note: *Because of the overwhelming favorable response of our first edition of the Drilling Rig Locator, it appears that the feature will be published on a quarterly basis.*

Taxation Article Reprinted

I am writing you in connection with the *Oil and Gas Tax Quarterly* of which I am editor.

I noted with interest the article, "Federal Taxation of Oil and Gas," written by Leland E. Fiske, appearing on pages A-54 to A-57 of the August, 1955, issue of *The Petroleum Engineer*. I telephoned Mr. Fiske to determine whether he would be agreeable to have the article reprinted in the *Oil and Gas Tax Quarterly*. He advised me that he was agreeable to this procedure, if you gave permission. Of course, we would give full credit to *The Petroleum Engineer* by a statement to the effect that the article was reprinted from the August, 1955, issue.

Will you kindly let me hear from you as to whether we may reprint Mr. Fiske's article?

Kenneth G. Miller.
Houston, Texas

Editor's Note: *Permission was granted for reprinting because of the importance of Leland E. Fiske's paper. Copies were also distributed to agents of the Internal Revenue Service to assist them in examining returns of oil operators. We believe "Federal Taxation of Oil and Gas" is one of the significant articles we have published this year.*

IDEA!

Hosts to Educators

Deans of colleges, heads of departments and professors from the country's leading universities and technical schools were the guests of Phillips Petroleum Company recently for a visit to offices and laboratories in Bartlesville, Oklahoma and to the company's manufacturing, research and other installations in the Borger, Texas area.

The 23 visitors represented 23 colleges and universities. The educators were from 15 states.

After visiting the research laboratory, business offices, instrumentation and geophysics laboratories, fuels and lubricants laboratory and other Phillips buildings in Bartlesville, the group traveled to Borger, Texas where they spent two days at Phillips installations, including the Philblack plant, the experiment station, chemical plants and refinery.

This is one of the most ambitious programs so far in informing educators of the work and operations of the oil industry. It certainly sets a pattern for other companies.